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A CONTRIBUTION TO THE ANALYSIS OF PRIMARY STRESSES IN THE HULL OF A RIGID AIRSHIP

BY

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Awarded the R.38 Memorial Prize for 1931 jointly with W. G. Bird, M.A., A.F.R.Ae.S., for his paper on "The Influence of Atmospheric Humidity and other Factors upon the Static Lift of Airships."

INTRODUCTION AND SUMMARY

1. This paper describes an investigation conducted at the request of the Aeronautical Research Committee, who made a grant to one of us for the purpose. It is submitted by permission as an essay to compete for the R.38 Memorial Prize.

No essential alteration has been made in the form of presentation adopted in our preliminary reports,[1] but to meet the needs of the general reader we have added the introductory paragraphs which follow. These explain briefly the nature of the problem which we have set ourselves, the range of our solution, and the bearing of our results on practical questions which confront the designer of a rigid airship hull.

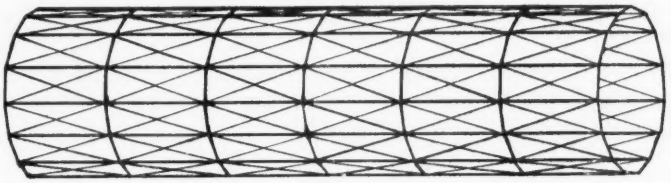


FIG. 1.

The Problem

2. We contemplate a tubular framework (Fig. 1), generally representative of airship hulls as these have been designed in recent years, but simplified to meet the requirements of our analysis. Longitudinal and crossed diagonal members are connected by pin joints to a series of transverse rings (or "bulkheads"), so as to form a cylindrical tube comprising any number of exactly similar bays. The shape of the cross-section is (for our purpose) immaterial, but it is convenient

[1] Three reports (T.3047, *a* and *b*) were presented to the Aeronautical Research Committee in December 1930, March 1931 and May 1931 respectively.

to fix attention upon the circle. All the longitudinals are assumed to be similar in respect of their elastic properties, and also all the diagonals; the relative elasticity of longitudinal and diagonal members is defined by an arbitrary parameter k.

3. We are concerned in this paper with the effects of forces applied at the joints of our tubular framework, and acting in directions parallel to the longitudinals; and to simplify the analysis of this problem we have made a further assumption which must be clearly recognised:—*We have assumed that the transverse rings, or bulkheads, are completely rigid against forces tending to distort them in their own planes.* Arguments will be adduced later (§ 11) to justify this assumption in an investigation which is intended to have some bearing on the problem of the rigid airship. Here it is only necessary to state the assumption, which amounts to the assertion that each bulkhead in Fig. 1 consists of a thin but inextensible disc.

On this understanding the cross-section of our tube will retain under all conditions its original shape, and hence the displacement of any particular joint can be completely specified by a single component w, the distance through which it moves in an axial direction, relatively to its initial (unstrained) position. Our problem is to determine w for every joint (from this we can of course proceed at once to calculate the stress in every longitudinal or diagonal member) when the applied forces, or the displacements of particular joints, are arbitrarily specified; as stated already, *in this paper we restrict our investigation to cases in which the applied forces are wholly axial.*

Nature of the Solution

4. Within these limitations we have obtained a complete and exact solution of our problem. Whatever the number of bays, and without restriction on the nature of the applied forces (except that they must, of course, be self-equilibrating), we have developed a procedure which is easy to understand and apply, and which does not—like the customary methods for dealing with highly redundant frameworks—involve the solution of a group of simultaneous equations, whether by determinants or otherwise.

The principles underlying our solution can be explained very simply. Stress distributions are shown to exist which have the characteristic that the axial displacements of corresponding joints in adjacent bulkheads, and the stresses in corresponding members of adjacent bays, have a constant ratio to one another; in the nature of the case, the displacements and stresses may increase either in one direction along the axis or in the other. Such stress distributions are here termed " normal "; in each the displacements vary from joint to joint of any one bulkhead in a perfectly definite way, and each requires, at a terminal bulkhead, a definite distribution of forces for the maintenance of equilibrium. If then the specified displacements or forces *at both ends of the tube* have this appropriate distribution, the stress system produced will be made up of two " normal " components, similar in type but with amplitudes increasing in opposite directions. Combining these in suitable proportions, we can satisfy two boundary conditions, *e.g.*, one for each end of our tube.

When the specified displacements or forces have not the distributions demanded by this simple solution, it is still possible to analyse them into a series of particular distributions, each of which lends itself to treatment on the lines just described. The number of distinct " normal " distributions is equal to the number of joints in a bulkhead, and therefore exactly what is required for this analysis. It might have been expected that the analysis would involve the solution of a number of simultaneous equations, but this does not prove to be the case; in Section VI of our paper we develop a method having many features of similarity with the method of " Fourier Analysis," and like it perfectly direct.

In the most general problem which can be set, forces or displacements are specified for every bulkhead of the tube considered. *Unless at one and the same bulkhead forces are specified for some joints and displacements for others* (a case which we do not consider in this paper), it is easy to see that the problem can be analysed into a series of distinct problems falling into one or other of the following categories:—

Displacements specified for both terminal bulkheads (treated in Section VII).

Forces specified for both terminal bulkheads (treated in Section IX).

One terminal bulkhead free; forces or displacements specified for the other (treated in Section XI).

One terminal bulkhead fixed; forces or displacements specified for the other (treated in Section XII).

Forces applied to the joints of an intermediate bulkhead; terminal bulkheads either free or fixed (treated in Section XIII).

Thus it may be claimed that our paper provides the designer with a means of obtaining, without an excessive expenditure of labour, exact solutions for a parallel tube having any number of bays; moreover, the labour increases hardly at all with an increasing number of bays. In this our method contrasts sharply with conventional methods for treating redundant frameworks, since the order of redundancy of our tube is proportional to the number of bays; indeed, it may be said that customary methods are entirely impracticable when the tube has more than two or three bays.

Nature of the "Normal" Stress Distributions

5. It will be clear from this description that " normal " stress distributions (defined as in §4) are the foundation upon which our whole treatment is based. In §§12 and 13 of this paper we give an equivalent but more mathematical definition: in a normal solution, if the displacement of any joint A in a given bulkhead is defined by component displacements u_A, v_A, w_A, then the corresponding joint in the next bulkhead[2] will undergo displacements λu_A, λv_A, λw_A, that of the next will undergo displacements $\lambda^2 u_A$, $\lambda^2 v_A$, $\lambda^2 w_A$, and so on, where λ is some definite numerical ratio, termed the " decay factor." In this paper we assume that the displacements are wholly axial, so that the displacement of A is in fact defined by a single quantity w_A. From the conditions for equilibrium of the joint A we find that w_A is related with w_B and w_N—the displacements of the joints, B and N, immediately adjoining A in its own bulkhead —by an equation which involves the decay factor;[3] and since a similar equation holds for every joint in the given bulkhead, we arrive (by elimination of the displacements w_A, w_B, . . . etc.) at an equation which must be satisfied by λ.

To each root of this equation in λ corresponds a definite relation between the displacements of the joints (A, B, . . . etc.) in any given bulkhead; and when this relation has been determined it is evident that the nature of the normal solution will be completely defined. As was to be expected, it is found that with every value of λ is associated, as another root of the equation, its reciprocal λ^{-1}. Both λ and λ^{-1} are associated with the same relation between the displacements of a given bulkhead: this means, that a displacement of normal type may decrease (or " decay ") in either direction along the axis of the tubular framework.[4]

6. The relation between the displacements in a given bulkhead can be stated very simply. Suppose that there are N joints in the bulkhead, which may be denoted by A, B, . . . N; and let α be written for the angle $2\pi/N$.[5] Then in the

[2] It is assumed that we pass along the tubular framework in a definite (positive) direction.
[3] Equation (13) of the paper.
[4] *Cf.* §17.
[5] *Cf.* equation (19).

particular case of a circular cross-section, if we define each joint by its angular position θ measured from the joint N, we shall have the following scheme of values :—

$$\left.\begin{array}{r} \text{For joint} \quad A,\ B,\ C,\ \ldots \qquad M,\ N, \\ \theta = a,\ 2a,\ 3a,\ \ldots\ (N-1)\,a,\ Na \end{array}\right\} \quad . \quad . \quad . \quad . \quad (1)$$

When the section is not circular, we may still associate these angles with the different joints, although they no longer have a definite geometrical significance. *Whatever be the shape of the cross-section,* " normal " solutions will exist in which either

$$w_{A,\ B,\ \ldots\ N} = \sin\{a \times [1,\ 2,\ \ldots\ N]\} \quad . \quad . \quad . \quad (2)$$

or

$$w_{A,\ B,\ \ldots\ N} = \cos\{a \times [1,\ 2,\ \ldots\ N]\} \quad . \quad . \quad . \quad (3)$$

and there will also exist other types of normal solution in which either

$$w_{A,\ B,\ \ldots\ N} = \sin\{na \times [1,\ 2,\ \ldots\ N]\} \quad . \quad . \quad . \quad (4)$$

or

$$w_{A,\ B,\ \ldots\ N} = \cos\{na \times [1,\ 2,\ \ldots\ N]\} \quad . \quad . \quad . \quad (5)$$

and n can have a range of integral values.

The normal solutions (4) and (5) will be briefly denoted by S_n and C_n; they evidently include (2) and (3) as particular cases. Referring to the scheme of values stated in (1), we may say that

$$\left.\begin{array}{l} w = \sin n\theta, \text{ in the normal solution } S_n, \\ \text{and } w = \cos n\theta, \text{ in the normal solution } C_n. \end{array}\right\} \quad . \quad . \quad . \quad (6)$$

7. It will be shown that in all cases N distinct types of normal solution exist. *When N is odd,* they may be denoted (in the notation which has just been introduced) by[6]

$$\left.\begin{array}{l} S_1,\ S_2,\ \ldots\ S_{\frac{1}{2}(N-1)} \\ \text{and } C_0,\ C_1,\ \ldots\ C_{\frac{1}{2}(N-1)} \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

When N is even, they may be denoted by

$$\left.\begin{array}{l} S_1,\ S_2,\ \ldots\ S_{(\frac{1}{2}N-1)} \\ \text{and } C_0,\ C_1,\ \ldots\ C_{\frac{1}{2}N} \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

8. As we have stated earlier (§5), a definite value of the decay factor λ (or of its reciprocal λ^{-1}) characterises each of these normal solutions: we have still to determine the value appropriate to each of the foregoing solutions. It will be shown in the paper that with S_n and C_n corresponds a definite value

$$\mu_n = -2\cos na \quad . \quad . \quad . \quad . \quad . \quad (9)$$

for a quantity which we denote by u; and that, knowing this value, we can determine the associated values of λ and λ^{-1} as being the roots of the quadratic equation

$$\lambda^2 - 2\lambda\,(k+2)/(k-\mu_n) + 1 = 0, \quad . \quad . \quad . \quad . \quad (10)$$

for a quantity which we denote by μ; and that, knowing this value, we can determine the tudinal and diagonal members.

The Analysis of a Specified System of Forces or Displacements

9. We are now in a position to determine completely the nature of each of the N distinct " normal " stress distributions which are associated with a tubular framework having N joints in each bulkhead; for it is a simple matter, knowing the displacements of every joint, to deduce the tension in every member. We can also determine what force is required at each joint of a terminal bulkhead in order to maintain the stress distribution; and thus the way is open for a treatment of problems such as we have classified in §4, by an analysis of the required

[6] The system C_0 consists of a unit displacement for every joint.

stress distribution into a series of superposed stress distributions, each of normal type.

The procedure required for this analysis is developed in Section VI of the paper. A summary is hardly possible, on account of the somewhat complicated notation which is entailed; but we may remark that no computation is involved beyond the summation of certain products of two numbers and the solution of quadratic equations. Examples worked in Sections VII-XIII of the paper should serve to explain the method.

Practical Applications

10. It remains to discuss the bearing of our investigation on the practical problem of rigid airship design.

An essay published in the Journal of the Royal Aeronautical Society for November, 1926,[7] summarised progress which had been made, up to the end of 1925, in the problem of primary stress determination for the hulls of rigid airships. The Report of the Airship Stressing Panel[8] had dealt with a tubular structure representative of an airship hull, making the usual assumptions that the stiffness of the joints may be neglected and that the loads are applied only at the joints. It obtained solutions which are sufficiently general to cover any possible type of resultant action on a bay; that is to say, its solutions can be employed when the forces applied at the joints of a transverse frame combine to give a force in any direction together with a couple about any axis. But these solutions will not be *exact* unless the forces which make up an action of specified type are distributed in a particular way, and no indication was given in the report as to the procedure which should be followed if in any particular instance the forces are distributed otherwise. What is still needed is a means for determining how the stress distribution is modified in such instances; in other words, we still have to investigate the problem which is presented when the forces applied to the joints of a transverse frame constitute a *self-equilibrating system*.

Such a system may comprise forces either in or perpendicular to the plane of the cross-section. The forces which act in the plane of the cross-section must themselves constitute a self-equilibrating system, and arguments can be adduced in support of the simplifying assumption that they will not involve appreciable stresses in members other than those of the transverse frame;[9] on this assumption, their investigation presents no great difficulty. The forces perpendicular to the cross-section will (to the same approximation) produce stresses only in the tubular " shell." In regard to the calculation of these it was considered (in 1926) " difficult to make general recommendations."[10] It is this problem that the present investigation is intended to elucidate.

The hull of a rigid airship is not, of course, cylindrical. But there is little prospect of any method being discovered which will permit an exact solution of the stresses in a hull of the conventional " cigar " form; and even if such should be forthcoming, it would be difficult to draw from a complete solution the kind of general indication which the designer most urgently requires. The point must not be forgotten, that the necessary scantlings for the girders and bracing wires of an airship can be decided only after a very large number of load conditions have been investigated: thus no reason is apparent for questioning the decision of the Airship Stressing Panel to aim at " the discovery of generalised formulæ, or methods—approximate only, but with more or less definite limits of error—

[7] " On the Calculation of Stresses in the Hulls of Rigid Airships." R. V. Southwell. (Also published by the Aeronautical Research Committee, R. & M. 1057.)
[8] Aeronautical Research Committee, R. & M. 800.
[9] *Cf.* R. & M. 1057, §3.62.
[10] *ibid.*

whereby the stress in any member of the structure can be related to the total action of the applied forces at the section in which that member lies."[11]

It has seemed to us consistent with this outlook to seek for guidance regarding the allowance to be made for " self-equilibrating systems " by examining the effects of these acting on a simplified framework—the cylindrical tube described in §2. The notion of analysis into a series of " normal " solutions, each associated with a certain characteristic rate of decay, would appear to have a value, even though the influence of taper upon these rates of decay cannot be exactly assessed. In fine, whilst we cannot claim that our exact solutions for a simplified framework are directly applicable to the airship, we believe that they will give designers more direct assistance in their problem than they would gain from any exact, but inevitably laborious, method for determining stresses in a complete hull structure.

11. Finally, we have to justify the assumption made in §3, that the transverse rings, or bulkheads, are completely rigid against forces tending to distort them in their own planes. This, we may claim,—although its chief merit lies in the simplification which it introduces,—is a logical application of ideas which were stated in the essay already quoted. In §§3.23 and 3.62 of R. & M. 1057 it was shown that there is in effect a partition of load between the " shell " and the bulkheads of an airship hull; " the function of the transverse rings is to prevent ' ovalling,' to which the shell, though ' stiff ' in the technical sense, offers only slight resistance; and . . . the members composing the ring will not be stressed by axial load or flexure, except to a very slight extent by interaction from the extension or contraction of the external ring members." We are confining attention in this paper (*cf.* §3) to the effects of (self-equilibrating) *longitudinal* forces, and for practical purposes, as has just been said, we require qualitative indications rather than exact results: it would hardly be reasonable to obscure our view of the way in which such effects tend to decay, by additional complexity introduced to make our investigation still more general.

Section I.

Statement of the Problem, and of Assumptions made in this Investigation

12. The nature of the framework considered has been described in §2 of the Introductory Section. We contemplate an ideal hull structure, generally representative of present day practice, but having the form of a cylindrical tube (not necessarily circular); and we imagine in the first place that axial forces—*self-equilibrating, but otherwise unrestricted*—are applied to the joints of one terminal bulkhead. In the analogous elastic problem of a uniform cylinder subjected to axial tractions on a terminal cross-section, we know that the stresses which are brought into play may be represented by a series of distinct " normal " systems, each characterised by a particular (exponential) law of variation with increasing distance from the loaded section. Accordingly we examine the possibility of performing a similar analysis in our present problem. The exponential law which is associated with the solid elastic cylinder may be expected to give place here to a type of variation in which corresponding stresses form a *geometrical progression* from bay to bay as the distance from the loaded section increases. So our tentative assumption in regard to the " normal " solutions which we are seeking is, that the stresses in any two adjoining bays are *similarly distributed*, but that their *intensity* is less in the more distant bay by a constant multiplier or " decay factor " λ. (In other words, we substitute an ordinary " compound interest law " for the exponential law which stands for " compound interest paid every moment ").

[11] *Cf.* R. & M. 800, Introductory Section.

13. The applied load system may be defined by specifying a value for the *force* at every joint, but a geometrical condition will then have to be imposed in order to ensure that the system is self-equilibrating: if, on the other hand, we specify the *displacement* of every joint, no question of equilibrium will arise. Accordingly we shall find it convenient to work at this stage in terms of joint displacements; we represent the displacement of any joint A by three component displacements u_A, v_A, w_A, and we assume that the corresponding joint of the adjacent transverse frame undergoes displacements λu_A, λv_A, λw_A. It is evident that on this assumption the stresses will vary from bay to bay in a similar manner.

14. In this preliminary investigation of the problem we shall make a further assumption, which introduces very great simplification and is not likely to involve any serious inaccuracy: *we shall assume that the transverse frames are completely rigid against distortion in their own planes.* On this understanding, the displacement of a joint is completely represented by its axial component w; further, only one condition of equilibrium (instead of three) will need to be satisfied at each joint, and we shall find that *this condition does not depend upon the geometry of the cross-section.* If, on the other hand, we were to allow distortion of the cross-section in its own plane, this last very great simplification would be lost.

SECTION II.

FORMULATION OF THE EQUATION GOVERNING THE "DECAY FACTOR"

15. The members which are concerned in the axial equilibrium of a joint A are those shown in heavy lines in the appended sketch (Fig. 2) of part of the tubular hull structure.[12]

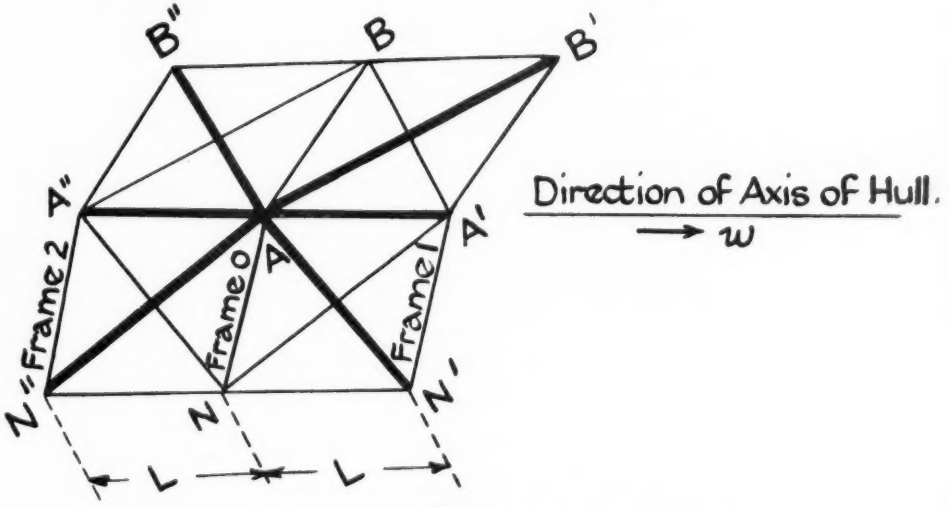


FIG. 2.

Representing the axial displacements of N, A and B (three adjacent joints in "Frame o") by w_N, w_A, w_B respectively, our fundamental assumption gives

[12] If N is the number of joints in each transverse frame, it will be appropriate to letter the first joint A and the last N, as in this diagram.

λw_N, λw_A, λw_B for the displacements of N', A', B' (the corresponding joints of "Frame 1"), and $\lambda^{-1}w_N$, $\lambda^{-1}w_A$, $\lambda^{-1}w_B$ for the displacements of N'', A'', B'' (the corresponding joints of "Frame 2"). The condition of equilibrium for A is (in the notation of tension coefficients)[13]

$$(T_{AA'} - T_{A''A}) + (T_{AB'} - T_{N''A}) + (T_{AN'} - T_{B''A}) = 0 \quad . \quad . \quad (11)$$

where, for example,

$$T_{AB'} = \Omega_{AB'} \cdot l_{AB'}{}^2 \cdot e_{AB'},$$
$$= \Omega_{AB'} \cdot L \cdot (w_{B'} - w_A),$$

and L is the length of a bay.

Putting in the assumed values for $w_{A'}$, etc., we have

$$\left.\begin{aligned} T_{AA'} &= \Omega_L \cdot L \cdot (\lambda - 1)\, w_A \\ T_{A''A} &= \Omega_L \cdot L \cdot (1 - 1/\lambda)\, w_A \\ T_{AB'} &= \Omega_D \cdot L \cdot (\lambda w_B - w_A) \\ T_{N''A} &= \Omega_D \cdot L \cdot (w_A - w_N/\lambda) \\ T_{AN'} &= \Omega_D \cdot L \cdot (\lambda w_N - w_A) \\ T_{B''A} &= \Omega_D \cdot L \cdot (w_A - w_B/\lambda) \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (12)$$

where Ω_L relates to a longitudinal and Ω_D to a diagonal member. *In this investigation we shall assume that Ω_L and Ω_D have constant values throughout the tubular structure.*

Substituting from (12) in (11), we obtain the equation

$$w_N + \mu w_A + w_B = 0 \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where

$$\mu = \{ (\lambda - 1)^2 \Omega_L - 4\lambda\Omega_D \} / (\lambda^2 + 1)\, \Omega_D \quad . \quad . \quad . \quad (14)$$

16. An equation of type (13) holds for each joint of the cross-section, μ having the same value in every case. The absolute magnitude of a displacement of given type will (by Hooke's law) be unrestricted, and hence we have in effect $(N-1)$ quantities (the ratios w_B/w_A, etc.) related by N equations. Eliminating the ratios, we obtain an equation in μ which must be satisfied in order that our fundamental assumption may hold. In determinantal form this equation is

$$\begin{vmatrix} \mu, & 1, & 0, & 0, & \ldots\ldots\ldots, & 1 \\ 1, & \mu, & 1, & 0, & \ldots\ldots\ldots, & 0 \\ 0, & 1, & \mu, & 1, & \ldots\ldots\ldots, & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0, & 0, & 0, & 0, & \ldots, & 1, \ \mu, \ 1 \\ 1 & 0, & 0, & 0, & \ldots, & 0, \ 1, \ \mu \end{vmatrix} = 0 \quad . \quad . \quad . \quad (15)$$

17. Since μ, by (14), can be expressed in terms of λ, equation (15) is really an equation governing the "decay factor" involved in our assumption. We observe that

$$\{ (1/\lambda - 1)^2 \Omega_L - 4\Omega_D/\lambda \} / (1/\lambda^2 + 1)\, \Omega_D = \{ (\lambda - 1)^2 \Omega_L - 4\lambda\Omega_D \} / (\lambda^2 + 1)\, \Omega_D \quad (16)$$

which shows that every value of λ satisfying (15) is associated with its reciprocal λ^{-1}. This is what we should expect, because a decay factor λ^{-1}, when axial distance is measured in one direction, is equivalent to a decay factor λ associated with axial distance measured in the reverse direction: in the nature of the case, there must be solutions corresponding with both directions. (Similarly, in the elastic problem mentioned in §12, a system of stresses characterised by the factor e^{az} will be associated with a similar system characterised by the factor e^{-az}.)

The relation of λ (and its reciprocal) with μ will depend upon the value of

$$k = \Omega_L/\Omega_D \quad . \quad . \quad . \quad . \quad . \quad (17)$$

[13] *Cf.* §2.48 of R. & M. 1057.

Fig. 3 shows the relation for $k=1, 2, 5, 10, 20$, when the values of μ range between ± 2; we shall find (§20) that this is the significant range for μ in our problem. A detailed discussion of equation (14) is given in Appendix I.

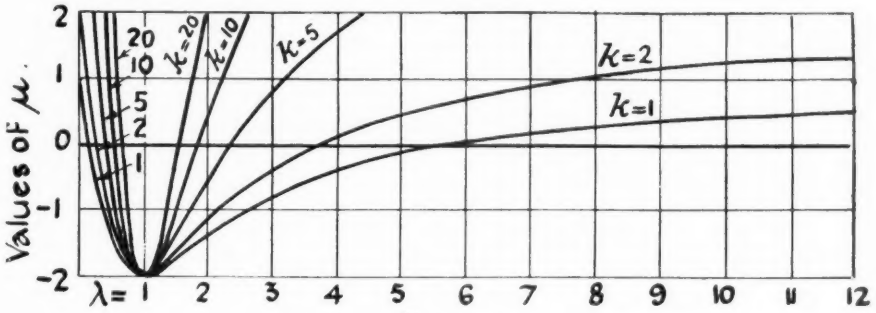


FIG. 3

Variation of λ with μ for different values of $k=\Omega_L/\Omega_D$.

SECTION III.

SOLUTION OF THE EQUATION GOVERNING THE "DECAY FACTOR"

18. We have now to determine the roots of our determinantal equation in μ.

We can at the same time solve this problem, and obtain information regarding the ratios w_B/w_A, etc. (which we eliminated in deriving the determinantal equation), if we revert to the N equations of type (13), and assume for trial that

$$w_{A, B, \ldots N}=\sin\{na\times[1, 2, \ldots N]\} \quad . \quad . \quad (4)\ bis$$

where a is an angle at present unspecified, and n is a numerical parameter.

The second equation of type (13), namely,

$$w_A+\mu w_B+w_C=0,$$

can then be written in the form

$$\sin na+\mu \sin 2na+\sin 3na=0,$$

or

$$\sin 2na\,(\mu+2\cos na)=0 \quad . \quad . \quad . \quad . \quad . \quad (i)$$

The third reduces similarly to

$$\sin 3na\,(\mu+2\cos na)=0 \quad . \quad . \quad . \quad . \quad . \quad (ii)$$

and so on up to the last equation, which takes the form

$$\sin(N-1)na+\mu\sin Nna+\sin na=0 \quad . \quad . \quad . \quad (iii)$$

The first of the N equations—namely, equation (13) itself—takes the form

$$\sin Nna+\mu\sin na+\sin 2na=0 \quad . \quad . \quad . \quad . \quad (iv)$$

It is now evident that all the equations, *except the first and last*, will be satisfied by the trial solution (4), if

$$\mu+2\cos na=0 \quad . \quad . \quad . \quad . \quad . \quad (18)$$

and the first and last, when this substitution is made, reduce respectively to

$$\left.\begin{aligned}&\sin Nna=0\\ \text{and to}\quad&\sin na-\sin(N+1)na=0\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (v)$$

These last two conditions will both be satisfied if (and only if) $Nn\alpha$ is zero or some integral multiple of 2π; that is,—if we write

$$\alpha = 2\pi/N \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

—*when n is integral or zero.* If, then, for the same values of n and α (18) is also satisfied, it is clear that our trial solution (4) will satisfy *all* the N equations of type (13).

19. It follows that $(\mu + 2\cos n\alpha)$ must be a factor of the determinant on the left of (15), provided that α and n have the restrictions just stated.

Now n may have any integral value, and to every value corresponds a factor $(\mu + 2\cos 2n\pi/N)$ of Δ_N. But by reference to equation (15) we see that Δ_N is of order N in μ, and that the coefficient of μ^N in the expansion of Δ_N is unity: we deduce that[14]

$$\Delta_N = (\mu + 2\cos 2\pi/N)(\mu + 2\cos 4\pi/N) \ldots (\mu + 2\cos 2N\pi/N) \quad . \quad (vi)$$

and hence, that the roots of (15) are given by

$$\mu = -2\cos\{(2\pi/N) \times [1, 2, 3, \ldots N]\} \quad . \quad . \quad . \quad (20)$$

For example:—

If $N=3$, $\mu = 1, 1, -2$.
If $N=4$, $\mu = 0, +2, 0, -2$.
If $N=6$, $\mu = -1, +1, +2, +1, -1, -2$.
If $N=8$, $\mu = -\sqrt{2}, 0, +\sqrt{2}, +2, +\sqrt{2}, 0, -\sqrt{2}, -2$.

In these simple cases, of course, direct expansion of the determinant Δ_N is practicable. We are thus able to impose a partial check on the result stated in (vi).

20. Fig. 4 exhibits diagrammatically the roots of (15) regarded as an equation in μ of the Nth degree. The roots are represented by small crosses, through which continuous curves may be drawn, as shown in dotted lines, to indicate the march of the roots with increasing N. (Of course, in the problem here considered, non-integral values of N have no real significance.)

We observe that all the roots lie in the range $-2 < \mu < 2$, as stated in §17.

Section IV.

Nature of the Displacements corresponding with Different Values of the "Decay Factor"

21. Reverting to §18, we have shown that the system of displacements given by (4) is consistent with the N equations of equilibrium, provided that the corresponding "decay factor" λ is a root of the quadratic equation (14), when μ is given the value

$$\mu_n = -2\cos n\alpha \quad . \quad . \quad . \quad . \quad . \quad (9)\ bis$$

Introducing the parameter k (defined in §17), we may write (14) as

$$\lambda^2 - 2\lambda(k+2)/(k-\mu_n) + 1 = 0, \quad . \quad . \quad . \quad (10)\ bis$$

which shows at once that λ and its reciprocal are associated roots.

An exactly similar argument can now be used to show that the system of displacements defined by

$$w_{A, B, \ldots N} = \cos\{n\alpha \times [1, 2, \ldots N]\} \quad . \quad . \quad (5)\ bis$$

will satisfy the N equations of equilibrium under the same conditions,—namely, when α is given by (19), n is integral, and λ (and its reciprocal) are derived from (9) and (10).

[14] A more rigorous investigation is given in Appendix II.

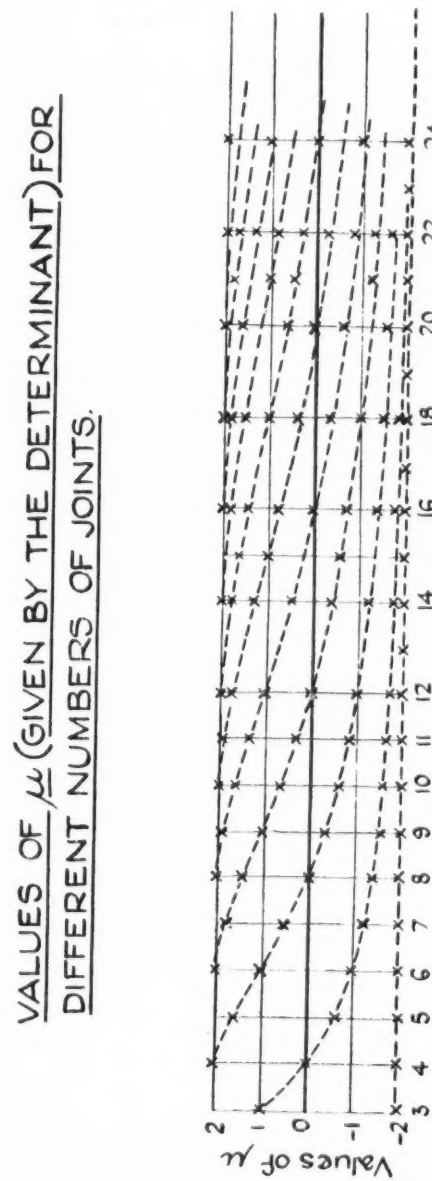

VALUES OF μ (GIVEN BY THE DETERMINANT) FOR DIFFERENT NUMBERS OF JOINTS.
Values of μ
2
1
0
-1
-2
3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24
N = Number of joints.

FIG. 4.

22. Thus we have arrived at two type solutions—namely, (4) and (5)—which are associated with the same decay factor. These solutions we shall represent, for brevity, by the symbols S_n and C_n respectively. Combining them in suitable proportions, we can (in effect) make any joint of a frame the starting point of our series (4) or (5). For example, the distribution represented by

$$S_n \cos 3n\alpha + C_n \sin 3n\alpha \quad . \quad . \quad . \quad . \quad . \quad (i)$$

is one in which

$$w_A = \sin n\alpha \cos 3n\alpha + \cos n\alpha \sin 3n\alpha,$$
$$= \sin 4n\alpha,$$
$$w_B = \sin 5n\alpha,$$

and so on. Thus the *type* of the distribution (i) is that represented by (4), but the joint A, which in (4) corresponds with the first term of the series on the right hand side, now corresponds with the fourth.

It thus is clear that we do *not* (as might have been expected) obtain new and independent solutions by merely changing the joint which is to be lettered A. On the other hand, C_n is evidently a solution distinct from S_n.[15] *Thus we have two, but only two, distinct solutions associated with any particular (integral) value of* n.

23. In special cases only one of these two solutions is significant.

Thus (*a*) when $n=N$, so that $n\alpha = 2\pi$, the displacement of every joint is zero in the solution of type (4), and unity in the solution of type (5). Accordingly S_N has no significance, and C_N *represents an axial translation of the bulkhead as a whole*. This last solution may conveniently be denoted by C_0, since it might equally have been obtained by making n zero in (5) and (9).

Thus to C_0 corresponds the value

$$\mu_0 = -2,$$

and Fig. 3 shows that the corresponding value of λ is unity. This means that every bulkhead is displaced by the same amount, so that the whole tube undergoes a rigid body displacement, and its members are unstressed; the solution accordingly has no practical significance.[16]

Again (*b*), when N is even and $n=\frac{1}{2}N$, so that $n\alpha=\pi$, the solution of type (4) again involves no displacement of any joint; but in this instance C_n involves displacements given by

$$w_{A,\ B,\ \ldots\ N} = -1,\ +1,\ -1,\ \ldots\ +1,$$

that is, *displacements equal in magnitude but alternating in sign*. μ_n is now equal to 2; and referring to Fig. 3 we see that λ_n and λ_n^{-1} depart in this case furthest from the value unity. What the value of λ_n will be depends, of course, on the ratio $k=\Omega_L/\Omega_D$; for values of k approximating to unity the rate of decay can evidently be very rapid.

Section V.

Number of the Normal Solutions which are Distinct

24. The aim of our investigation (*cf.* §4) is to construct solutions to specified problems by a synthesis of stress distributions of "normal" type; and for this purpose we must have a method whereby any set of N specified quantities (*e.g.*, displacements), *one for each joint of a given bulkhead*, can be analysed into a series of components of type S_n or C_n. It is not difficult to see that such analysis will be possible only if N (in all) distinct solutions of these types exist, *and that the representation in series will not be unique if more than N distinct solutions exist*. Hence it becomes necessary to examine the conditions which must hold

[15] *Cf.* §24.
[16] *Cf.*, however, *infra* §29.

if S_m, S_n, or C_m, C_n, are to be distinct solutions. It is at once evident that any solution of type S_n must be distinct from any solution of type C_n; for (4) shows that w_N is zero in the first type, whereas (5) shows that w_N has a finite value in the second.

25. Let $(w_J)_m$ stand for the displacement of a particular joint J in the "normal" solution S_m, and $(w_J)_n$ for the displacement of the same joint in the normal solution S_n. We form the product $(w_J)_m \cdot (w_J)_n$, and we sum the products thus obtained for every joint.

Then if J is the jth joint measured from N, we have from (4)

$$(w_J)_m \cdot (w_J)_n = \sin mj\alpha \cdot \sin nj\alpha,$$
$$= \tfrac{1}{2} \{ \cos (m-n) j\alpha - \cos (m+n) j\alpha \},$$

and hence

$$\sum_N [(w_J)_m \cdot (w_J)_n]$$
$$= \tfrac{1}{2} [\cos \beta + \cos 2\beta + \ldots + \cos N\beta] - \tfrac{1}{2} [\cos \gamma + \cos 2\gamma + \ldots + \cos N\gamma],$$
$$= \{ \cos (N+1) \beta/2 \cdot \sin N\beta/2 \} / (2 \sin \beta/2)$$
$$- \{ \cos (N+1) \gamma/2 \cdot \sin N\gamma/2 \} / (2 \sin \gamma/2), \quad (21)$$

where $\beta = (m-n)\alpha$, $\gamma = (m+n)\alpha$.

Since, by (19), we have

$$N\beta/2 = (m-n)\pi, \qquad N\gamma/2 = (m+n)\pi,$$

it is clear that the right hand side of (21) will vanish unless one or other of β and γ are integral multiples of 2π, *i.e.*, unless one or other of $(m-n)/N$ and $(m+n)/N$ is either integral or zero.

26. But the left hand side of (21) cannot vanish if S_m and S_n are identical; for then we should have

$$(w_J)_m \cdot (w_J)_n = \{ (w_J)_m \}^2,$$

and every term in the summation would be positive. We conclude that S_m and S_n are distinct solutions unless one or other of $(m-n)/N$ and $(m+n)/N$ is integral or zero; and it follows that distinct solutions of type S_n will be obtained if we give to n, in (4), the successive values:—

$$\left.\begin{array}{l} 1, 2, \ldots \tfrac{1}{2}(N-1), \textit{ when } N \textit{ is odd}, \\ 1, 2, \ldots (\tfrac{1}{2}N-1), \textit{ when } N \textit{ is even}. \end{array}\right\} \quad . \quad . \quad . \quad (22)$$

(We have seen in §23 that the values 0 or $\frac{1}{2}N$ (when N is even) do not lead to significant solutions.)

27. If now we consider in the same way two solutions, C_m and C_n, of the form given by (5), the only alteration is a change of sign in the second term on the right hand side of (21); and the conclusion is reached that C_m, C_n are distinct solutions, unless one or other of $(m-n)/N$ and $(m+n)/N$ is integral or zero. In this case, however, a zero value for n is significant, as well as the value $\frac{1}{2}N$ when N is even; and we deduce that distinct solutions of type C_n are obtained if we give to n, in (5), the successive values

$$\left.\begin{array}{ll} 0, 1, 2, \ldots \tfrac{1}{2}(N-1), & \textit{when } N \textit{ is odd}, \\ 0, 1, 2, \ldots \tfrac{1}{2}N, & \textit{when } N \textit{ is even}. \end{array}\right\} \quad . \quad . \quad (23)$$

28. Combining the solutions given by (22) and (23),[17] we see that N *distinct solutions of normal type can be found, whether* N *be odd or even;* and reverting to (4) and (5) we may show that no greater number can exist. Thus, if we make n equal to $(N-p)$, where p is integral and less than $\frac{1}{2}N$, we have

$$n\alpha = (2\pi - p\alpha),$$

and (4) becomes

$$w_{A, B, \ldots N} = -\sin \{ p\alpha \times [1, 2, \ldots N] \},$$

showing that the new solution is identical, except as regards sign, with S_p.

We have thus arrived at precisely the result which in §24 we showed to be

[17] *Cf.* Introduction, (7) and (8).

required for further advance: *in every case N distinct types of normal solution, and only N, have been shown to exist.*

29. With each solution correspond two values of the decay factor, namely λ and λ^{-1}. These values will be different unless $\lambda = 1$, that is (Fig. 3), unless $\mu = -2$; and (18) and (19) show that in this case n must either be zero or a multiple of N. It follows that C_0 is the only solution which, under the restrictions stated in (22) and (23), is associated with a decay factor unity.

Now it will be necessary in what follows that two solutions shall correspond with any particular value of the decay factor. Accordingly we are led to inquire what other solution can be described as of "type C_0," besides the rigid body displacement contemplated in §23. As before, each bulkhead must be displaced as a whole; and it is evident that the required solution is one in which the *stresses* are the same in every bay, *but the bulkhead displacements increase from bay to bay in arithmetical, instead of geometrical, progression.*

Section VI.

Representation of any Arbitrary System of Displacements as a Series of "Normal" Systems

30. We are now in a position to undertake the problem mentioned at the beginning of §24; that is, to analyse a set of N specified quantities (*e.g.*, displacements)—one for each joint of a given bulkhead—into a series of components of types S_n and C_n. Assuming that the analysis is possible, we have to find values for the coefficients $A_1, A_2, \ldots B_0, B_1, B_2, \ldots$, such that an expression of the type

$$w = A_1 . S_1 + A_2 . S_2 + \ldots + A_n . S_n + \ldots + B_0 . C_0 + B_1 . C_1 + B_2 . C_2 + \ldots + B_n . C_n + \ldots \qquad (24)$$

will hold in respect of every one of the N joints. In this expression w, on the left hand side, stands for the specified displacement of the joint in question, and S_n and C_n stand for the displacement of that joint in a normal solution of the type (4) and (5) respectively, so that (*e.g.*) for the joint J we have

$$w_J = A_1 \sin j\alpha + A_2 \sin 2j\alpha + \ldots + A_n \sin nj\alpha + \ldots + B_0 + B_1 \cos j\alpha + B_2 \cos 2j\alpha + \ldots + B_n \cos nj\alpha + \ldots \qquad (25)$$

In conformity with the results established in (22) and (23), we may say that

$$\left.\begin{array}{llllllll} \textit{If } N \textit{ is odd,} & \text{the coefficients of type } A_n & \text{will extend to} & A_{\frac{1}{2}(N-1)} \\ \text{and} & \text{,,} \quad \text{,,} & \text{,,} & B_n & \text{,,} & \text{,,} & B_{\frac{1}{2}(N-1)} \\ \textit{If } N \textit{ is even,} & \text{,,} \quad \text{,,} & \text{,,} & A_n & \text{,,} & \text{,,} & A_{(\frac{1}{2}N-1)} \\ \text{and} & \text{,,} \quad \text{,,} & \text{,,} & B_n & \text{,,} & \text{,,} & B_{\frac{1}{2}N} \end{array}\right\} . \qquad (26)$$

Since in every case the A series starts from A_1 and the B series from B_0, we see that N coefficients will always be entailed.

31. To determine the values of A_n or B_n we make use of results which have been established in §§25 and 27. Multiplying each side of (25) by $\sin nj\alpha$, and summing the equations so found for every joint, we obtain

$$\sum_N [w_J . \sin nj\alpha] = A_1 \sum_N [\sin j\alpha . \sin nj\alpha] + A_2 \sum_N [\sin 2j\alpha . \sin nj\alpha] + \ldots + B_0 \sum_N [\sin nj\alpha] + B_1 \sum_N [\cos j\alpha . \sin nj\alpha] + \ldots \qquad (27)$$

The coefficient of A_m, in the right hand side of (27), is

$$\sum_N [\sin mj\alpha . \sin nj\alpha],$$

and the argument of §25 shows that this must vanish unless $m = n$. For $\sin \beta/2$ and $\sin \gamma/2$, on the right of (21), cannot vanish unless one or other of $(m-n)/N$ and $(m+n)/N$ is integral or zero; and the restrictions expressed in (26) limit this possibility to the case when m and n are equal.

32. Again, the coefficient of C_m, in the right hand side of (27), is

$$\sum_N [\cos mj\alpha \,.\, \sin nj\alpha]$$

$$= \tfrac{1}{2}[\sin\gamma + \sin 2\gamma + \ldots + \sin N\gamma] - \tfrac{1}{2}[\sin\beta + \sin 2\beta + \ldots + \sin N\beta],$$

$$= \{\sin(N+1)\gamma/2 \,.\, \sin N\gamma/2\}/(2\sin\gamma/2)$$

$$- \{\sin(N+1)\beta/2 \,.\, \sin N\beta/2\}/(2\sin\beta/2), \qquad (28)$$

where $\beta = (m-n)\alpha$, $\gamma = (m+n)\alpha$, as before.

By similar arguments we can show that the right hand side of (28) will vanish unless one or other of β and γ is zero. But now it will evidently vanish in this case too, because if β is zero every term in the series

$$\sin\beta + \sin 2\beta + \ldots \text{ etc.}$$

will vanish, and a similar result holds in relation to γ.

33. We deduce that equation (27) reduces to the form

$$\sum_N [w_j \,.\, \sin nj\alpha] = A_n \sum_N [\sin^2 nj\alpha] \qquad . \quad . \quad . \qquad (29)$$

and we can show in the same way that

$$\sum_N [w_j \,.\, \cos nj\alpha] = B_n \sum_N [\cos^2 nj\alpha] \qquad . \quad . \quad . \qquad (30)$$

Again, we have

$$\sum_N [\sin^2 nj\alpha] = \tfrac{1}{2}\sum_N [1 - \cos 2nj\alpha]$$

$$= N/2 - \{\cos(N+1)n\alpha \,.\, \sin Nn\alpha\}/(2\sin n\alpha),$$

by the trigonometrical formula used previously,

$$= N/2, \text{ when } n \text{ is restricted as in (22).}$$

Unless n has the value 0 or $\frac{1}{2}N$, we can show in the same way that

$$\sum_N [\cos^2 nj\alpha] = N/2.$$

When $n=0$ it is clear that

$$\sum_N [\cos^2 nj\alpha] = \sum_N [1] = N;$$

and when $n = \frac{1}{2}N$ we have from (19)

$$\sum_N [\cos^2 nj\alpha] = \sum_N [\cos^2 j\pi] = N.$$

Hence, finally, we can express equations (29) and (30) as follows:—

$$\left.\begin{aligned} A_n &= (2/N)\sum_N [w_j \,.\, \sin nj\alpha], \\ B_0 &= (1/N)\sum_N [w_j], \\ B_n &= (2/N)\sum_N [w_j \,.\, \cos nj\alpha] \quad (0 < n < \tfrac{1}{2}N), \\ B_{\frac{1}{2}N} &= (1/N)\sum_N [w_j \,.\, \cos j\pi]. \end{aligned}\right\} \quad . \quad . \qquad (31)$$

Thus the analysis expressed by (24) can be effected by a process involving no calculation other than simple multiplication and addition.

SECTION VII.

APPLICATION TO THE PROBLEM OF PRIMARY STRESS DETERMINATION FOR A TUBE HAVING ANY NUMBER OF BAYS, WHEN THE DISPLACEMENTS OF THE TERMINAL SECTIONS ARE SPECIFIED

34. When the displacements are specified (at every joint) for *both* terminal sections of a tube such as we are considering, the methods outlined in Section VI may be applied to analyse the displacements at either end into a series of the type (24). Taking the z-axis to be directed from left to right (as in Fig. 2) we

may represent the displacement of the left hand terminal section by w and the displacement of the right hand terminal section by $\bar{w}$; and we may assume that w has been analysed into the series (24), *with known coefficients*, and $\bar{w}$ into the corresponding series

$$\bar{w} = \bar{A}_1 . S_1 + \bar{A}_2 . S_2 + \ldots + \bar{A}_n . S_n + \ldots + \bar{B}_0 . C_0 + \bar{B}_1 . C_1 + \ldots + \bar{B}_n . C_n + \ldots \quad . \quad . \quad (32)$$

Then from (24) and (32) we see that the component system of type S_n attains an " amplitude " A_n at the left hand section and an amplitude $\bar{A}_n$ at the right hand section. Now a system of this type is characterised by a " decay factor " which may assume either of the two values, λ_n or λ_n^{-1}, deduced from equation (10) after giving μ_n the value $-2 \cos n\alpha$. Assume then that the component is made up of two parts: the first of amplitude P_n at the left hand section, and characterised by a decay factor λ_n; and the second of amplitude Q_n at the left hand section, and characterised by a decay factor λ_n^{-1}. *Let β be the number of bays in the tube which we are considering.* Then at the right hand section the first part will have an amplitude $P_n (\lambda_n)^\beta$ and the second part an amplitude $Q_n (\lambda_n)^{-\beta}$: so we have the relations

$$\left.\begin{aligned} P_n + Q_n &= A_n \\ P_n (\lambda_n)^\beta + Q_n (\lambda_n)^{-\beta} &= \bar{A}_n \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (33)$$

whence P_n and Q_n can be determined; and then the amplitude of the component system S_n, at a frame distant r bays from the left hand terminal bulkhead, will be given by

$$[A_n]_{\text{Frame } r} = P_n (\lambda_n)^r + Q_n (\lambda_n)^{-r} \quad . \quad . \quad . \quad (34)$$

35. Exactly the same analysis applies to the component systems of type C_n, except that special considerations arise in the case of the first system C_0. This system was discussed in §29, where it was shown that the corresponding stress distribution is characterised by a decay factor of value unity, but that the displacements, in consequence, form an arithmetical (instead of geometrical) progression as we pass from bay to bay.

Thus the formulæ (33) and (34) are inapplicable when $n = 0$. We know that the amplitude of the system C_0 changes by arithmetical progression from its value B_0 at the left hand terminal section to its value $\bar{B}_0$ at the right hand terminal section. Therefore the formula (34) may be replaced by

$$[B_0]_{\text{Frame } r} = B_0 + (r/\beta)(\bar{B}_0 - B_0) \quad . \quad . \quad . \quad (35)$$

36. *Illustrative Example.*—In illustration of the foregoing discussion, complete calculations have been made for a tube of fifteen sides and six bays. It will be appreciated that the redundancy is here of an order which precludes any idea of solution by orthodox " strain energy " methods.

Fig 5 shows the arbitrary system of displacements which is assumed to have been imposed on the terminal bulkheads. As explained in §§6 and 14, the geometrical form of the cross-section is in fact quite unrestricted; but in this diagram the sections have been shown as regular polygons, simply to fix ideas. The angular positions of the joints have been measured in a clockwise direction from the joint A as datum.

The first step in the calculation is to evaluate the coefficients $A_1, \ldots$ etc., in the series (24) and (32). In Table I (of which only a part is here reproduced), column (1) gives the joints in order, column (2) the specified displacement of each joint in the left hand terminal bulkhead, and column (3) the angular position θ in degrees. Column (4) gives the displacements of the joints in the system S_1:

referring to equation (4), we see that these are calculable from the formula

$$\text{Displacement in system } S_1 = \sin\theta,$$

and that, similarly,

$$\text{Displacement in system } S_2 = \sin 2\theta,$$

and so on.[18]

In column (5), the product of columns (2) and (4),—that is, of the specified displacement and the displacement in system S_1,—is formed for each joint. These products are summed, and divided by $N/2$ ($=7{\cdot}5$) to give the value of A_1. The remaining columns (of which only (6) and (7) are here reproduced) are similar to columns (4) and (5).

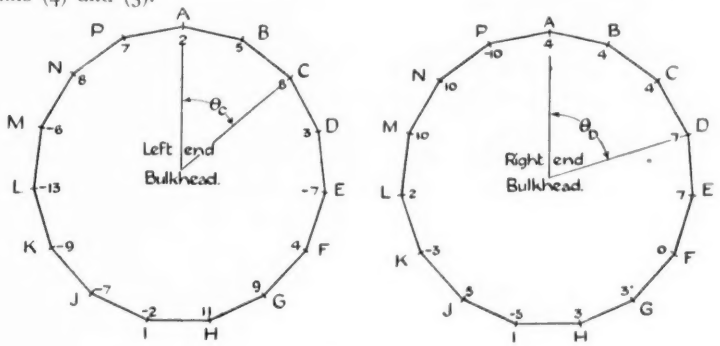


FIG. 5.

TABLE I.

Determination of Coefficients in the Series (24).

(1) Joint	(2) Specified Displacement w	(3) Angular Position θ	(4) Displacement in System S_1 ($=\sin\theta$)	(5) Product of (2) and (4)	(6) Displacement in System S_2 ($=\sin 2\theta$)	(7) Product of (2) and (6)
A	2	0	0	0	0	0
B	5	24	0.4067	2.0335	0.7431	3.7155
C	8	48	0.7431	5.9448	0.9945	7.9560
D	3	72	0.9510	2.8530	0.5878	1.7634
E	−7	96	0.9945	−6.9615	−0.2079	1.4553
F	4	120	0.8660	3.4640	−0.8660	−3.4640
G	9	144	0.5878	5.2902	−0.9510	−8.5590
H	11	168	0.2079	2.2869	−0.4067	−4.4737
I	−2	192	−0.2079	0.4158	0.4067	−0.8134
J	−7	216	−0.5878	4.1146	0.9510	−6.6570
K	−9	240	−0.8660	7.7940	0.8660	−7.7940
L	−13	264	−0.9945	12.9285	0.2079	−2.7027
M	−6	288	−0.9510	5.7060	−0.5878	3.5268
N	8	312	−0.7431	−5.9448	−0.9945	−7.9560
P	7	336	−0.4067	−2.8469	−0.7431	−5.2017
Sum	13			37.0781		−29.2045
	÷15			÷7·5		÷7·5
	$=B_0$			$=A_1$		$=A_2$

[18] *Cf.* §6, Equations (1) and (6), of the Introductory Section. Hitherto we have used N to denote the number of joints in a bulkhead, and the joint immediately adjoining A as datum. No confusion should be caused by the altered convention which is here adopted.

TABLE II.

(1) Suffix	(2) Left end Bulkhead	(3) Right end Bulkhead	(4) (For $k=10$)	(5)	(6)	(7)	(8) First Bulkhead	(9) Second Bulkhead	(10) Third Bulkhead	(11) Fourth Bulkhead	(12) Fifth Bulkhead
n	A_n	$\overline{A_n}$	λ_n	λ_n^{-1}	P_n	Q_n	A_n	A_n	A_n	A_n	A_n
1	4·9437	0.8587	1.1861	0.8431	−0.3779	5·3216	4.0384	3.2510	2.5587	1.9411	1.3799
2	−3.8939	−0.3088	1.4051	0.7117	0.0260	−3.9199	−2.7533	−1.9341	−1.3410	−0.9041	−0.5734
3	1.3279	1.2795	1.6568	0.6036	0.0599	1.2690	0.8636	0.6240	0.5469	0.6122	0.8369
4	−2.1220	2.3848	1.9342	0.5170	0.04634	−2.1683	−1.0314	−0.4062	0.0357	0.4938	1.1745
5	0.4619	3.4640	2.2152	0.4514	0.02928	0.4326	0.2602	0.2318	0.3581	0.7235	1.5699
6	0.1198	−0.0854	2.4560	0.4072	0.000392	0.1202	0.0480	0.0176	0.00231	−0.0110	−0.0337
7	1.2515	1.6437	2.5988	0.3848	0.00532	1.2462	0.4933	0.2205	0.1614	0.2700	0.6411
	B_n	$\overline{B_n}$					B_n	B_n	B_n	B_n	B_n
0	0.8667	2.7333	1.0000	1.0000			1.1778	1.4889	1.8000	2.1111	2.4222
1	2.2546	1.2247	1.1861	0.8431	0.1712	2.0834	1.9596	1.7217	1.5342	1.3915	1.2894
2	5·5581	−2.9185	1.4051	0.7117	−0.4812	6.0393	3.6219	2.1089	0.8423	−0.3266	−1.5327
3	−3.0203	−2.5416	1.6568	0.6036	−0.1161	−2.9042	−1.9453	−1.3767	−1.1667	−1.2602	−1.6820
4	−3.6262	−0.2536	1.9342	0.5170	−0.00352	−3.6227	−1.8797	−0.9814	−0.5251	−0.3077	−0.2290
5	−0.6667	3.0667	2.2152	0.4514	0.0260	−0.6927	−0.2551	−0.0136	0.2189	0.5974	1.3739
6	1.1536	0.1416	2.4560	0.4072	0.000621	1.1530	0.4710	0.1948	0.0870	0.0543	0.0684
7	−0.5198	2.5477	2.5988	0.3848	0.008275	−0.5281	−0.1816	−0.0222	0.1151	0.3658	0.9761

In Table II, columns (2) and (3) summarise the results of the foregoing calculations, by giving values of A_n, A_n, B_n, $\overline{B}_n$ for values of the suffix n which are stated in column (1). Reference to (26) of §30 shows that in this example the suffix n will range from 1 to 7 for systems of type S_n and from 0 to 7 for systems of type C_n.

Columns (4) and (5) give the values of λ and λ^{-1} which correspond with these values of n. Since these quantities have in what follows to be raised to the sixth power, it is necessary to calculate them accurately from (10), and not merely to read off values from a curve such as Fig. 3. This matter is discussed in Appendix I: *for the purpose of the present example a value* 10 *has been assumed for the elasticity ratio* k.

Columns (6) and (7) give the values of P_n and Q_n, derived from (33), for values of n ranging from 1 to 7; and the remaining columns are an application of (34) to calculate the amplitudes of the different component systems at the first, second, . . . fifth intermediate bulkhead.

Table III summarises (for the first four joints) the process of deducing the actual displacements of joints in the third bulkhead. Each joint is given a separate column, and on successive lines are inserted the contributions of the different systems S_1, . . . etc. Thus (for example) the contribution of S_5 to the displacement of any joint is

$$A_5 \sin 5\theta,$$

where θ is the angular position of the joint in question (*cf.* column (3) of Table I), and A_5 is the amplitude of the system S_5 in the third bulkhead (column (10) of Table II). At the bottom of the table the contributions are summed to give the resultant displacement of each joint; the contributions of the S_n and C_n systems are summed separately, since their difference will give the displacements of other joints in the series.

Table IV gives the collected results, and Fig. 6 exhibits them diagrammatically.

At every stage in the calculation checks of an obvious nature (which it is not necessary to discuss) can be imposed. The final check is a verification that every joint in the intermediate bulkheads is in equilibrium.

TABLE III.

Displacements at Third Bulkhead.

Contribution of System		Joint A	B	C	D
$S_1 =$	$A_1 \sin \theta$	0	1.0406	1.9014	2.4333
$S_2 =$	$A_2 \sin 2\theta$	0	−0.9965	−1.3336	−0.7882
$S_3 =$	$A_3 \sin 3\theta$	0	0.5201	0.3215	−0.3215
$S_4 =$	$A_4 \sin 4\theta$	0	0.0355	−0.0074	−0.0339
$S_5 =$	$A_5 \sin 5\theta$	0	0.3101	−0.3101	0
$S_6 =$	$A_6 \sin 6\theta$	0	0.0014	−0.0022	0.0022
$S_7 =$	$A_7 \sin 7\theta$	0	0.0341	−0.0669	0.0966
	Sum	0	0.9453	0.5027	1.3885
$C_0 =$	B_0	1.8000	1.8000	1.8000	1.8000
$C_1 =$	$B_1 \cos \theta$	1.5342	1.4015	1.0265	0.4741
$C_2 =$	$B_2 \cos 2\theta$	0.8423	0.5636	−0.0880	−0.6814
$C_3 =$	$B_3 \cos 3\theta$	−1.1667	−0.3605	0.9439	0.9439
$C_4 =$	$B_4 \cos 4\theta$	−0.5261	0.0550	0.5146	−0.1626
$C_5 =$	$B_5 \cos 5\theta$	0.2189	−0.1095	−0.1095	0.2189
$C_6 =$	$B_6 \cos 6\theta$	0.0870	−0.0704	0.0269	0.0269
$C_7 =$	$B_7 \cos 7\theta$	0.1151	−0.1126	0.1051	−0.0931
	Sum	2.9047	3.1671	4.2195	2.5267

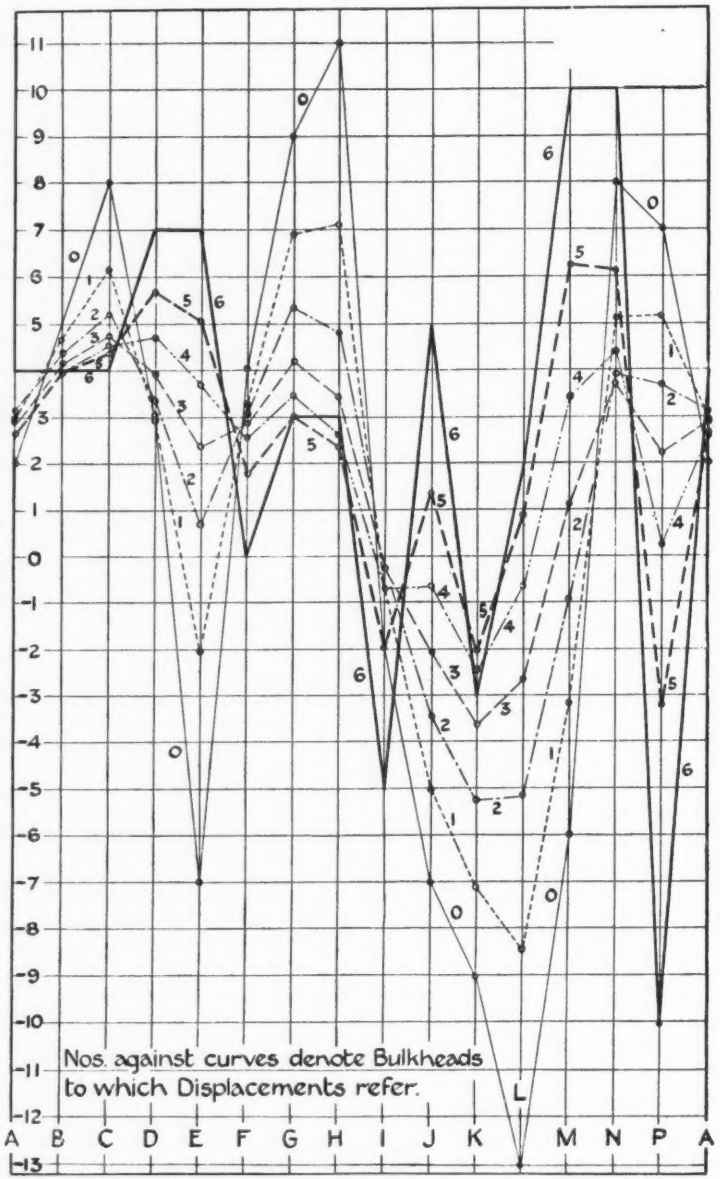

Nos. against curves denote Bulkheads
to which Displacements refer.
A B C D E F G H I J K L M N P A

FIG. 6.

TABLE IV.

Joint	Displacements at Bulkheads.						
	Left End	First	Second	Third	Fourth	Fifth	Right End
A	2	2.969	3.120	2.905	2.626	2.686	4
B	5	4.659	4.352	4.112	3.973	3.954	4
C	8	6.143	5.177	4.722	4.524	4.370	4
D	3	2.914	3.310	3.915	4.681	5.667	7
E	−7	−2.084	0.662	2.376	3.686	5.045	7
F	4	3.261	3.029	2.868	2.544	1.774	0
G	9	6.918	5.321	4.192	3.440	3.024	3
H	11	7.081	4.792	3.410	2.615	2.369	3
I	−2	−0.726	−0.277	−0.278	−0.724	−1.968	−5
J	−7	−5.040	−3.445	−2.055	−0.619	1.359	5
K	−9	−7.119	−5.228	−3.612	−2.454	−2.035	−3
L	−13	−8.441	−5.144	−2.632	−0.653	0.892	2
M	−6	−3.148	−0.931	1.138	3.415	6.245	10
N	8	5.117	3.904	3.717	4.374	6.141	10
P	7	5.163	3.690	2.222	0.239	−3.190	−10

37. Table V shows the longitudinal forces which must be applied at the terminal bulkheads in order to maintain the specified displacements of the joints. The sum of these forces gives the resultant action on the section,—namely, the action which tends to stretch the tube as a whole. In this calculation an arbitrary value, unity, has been assigned to the quantity $L^2\Omega_D$, which is a measure of the stiffness of the framework: thus in any other instance the stresses have only to be multiplied by the appropriate value of $L^2\Omega_D$. As stated already (§36), k has been assumed to have the value 10.

TABLE V.

Joint	Applied Longitudinal Force	
	Left End	Right End
A	15.51	20.37
B	−4.30	1.40
C	−27.00	−5.33
D	−2.80	17.91
E	69.33	26.11
F	−10.56	−25.81
G	−28.48	1.62
H	−54.99	11.26
I	18.78	−44.05
J	25.76	50.41
K	23.33	−17.90
L	61.32	10.87
M	37.20	50.52
N	−42.82	55.54
P	−24.29	−96.93
Sum	55.99	55.99

SECTION VIII.

TERMINAL FORCES INVOLVED BY A GIVEN SYSTEM OF TERMINAL DISPLACEMENTS

38. The calculations involved in Table V may be explained as follows:—Referring to Fig. 2 (§15), let us imagine that the frame $N''A''B''$ is removed, so that NAB becomes the left hand terminal bulkhead of our tube. Then a

longitudinal force at A is required to balance the forces which are exerted by AB', AA', AN'; its magnitude is given by

$$\begin{aligned} Z_A &= L\,(T_{AB'} + T_{AA'} + T_{AN'}) \\ &= L^2\,\{\,\Omega_{AB'}\,(w_{B'} - w_A) + \Omega_{AA'}\,(w_{A'} - w_A) + \Omega_{AN'}\,(w_A - w_{N'})\,\} \end{aligned}$$

if we make use of the formula which follows equation (11),

$$\begin{aligned} &= L^2\,\{\,\Omega_D\,(w_{B'} + w_{N'} - 2w_A) + \Omega_L\,(w_{A'} - w_A)\,\} \\ &= L^2 \,.\, \Omega_D\,\{\,u_{B'} + w_{N'} - 2w_A + k\,(w_{A'} - w_A)\,\} \quad . \quad . \quad . \quad . \quad (36) \end{aligned}$$

by (17).

A positive sign for this expression will indicate that the force tends to *stretch* the tube.

Similar expressions hold for the forces at every other joint of the terminal frame, and enable the forces to be calculated, once the displacements have been determined for the terminal frame and for the frame which adjoins it.

Again referring to Fig. 2, and imagining now that the frame $N'A'B'$ is removed, we may think of NAB as the right hand terminal bulkhead of the tube. The force required at A is now given by

$$\begin{aligned} Z_A &= L\,(T_{AB''} + T_{AA''} + T_{AN''}) \\ &= L^2\,\{\,\Omega_{AB''}\,(w_A - w_{B''}) + \Omega_{AA''}\,(w_A - w_{A''}) + \Omega_{AN''}\,(w_A - w_{N''})\,\} \\ &= L^2 \,.\, \Omega_D\,\{\,2w_A - w_{N''} - w_{B''} + k\,(w_A - w_{A''})\,\} \quad . \quad . \quad . \quad . \quad (37) \end{aligned}$$

Here again, a positive sign will indicate that the force tends to stretch the tube.

Section IX.

Primary Stress Determination for a Tube having any Number of Bays, when the Longitudinal Forces on the Terminal Bulkheads are Specified

39. Assuming now, as a special case, that the displacement is of "normal" type and so associated with a decay factor λ, we may write in (36)

$$u_{A'} = \lambda w_A, \ldots \text{etc.},$$

and then we find that

$$\begin{aligned} Z_A &= L^2 \,.\, \Omega_D\,[\lambda\,(w_B + w_N) + \{\,k\,(\lambda - 1) - 2\,\}\,w_A] \\ &= L^2 \,.\, \Omega_D\,[k\,(\lambda - 1) - \mu\lambda - 2]\,w_A, \end{aligned}$$

in virtue of the relation (13).

Substituting for μ from (14), we have finally

$$Z_A = w_A \,.\, L^2 \,.\, \Omega_D\,(k + 2)\,(\lambda^2 - 1)/(\lambda^2 + 1) \quad . \quad . \quad (38)$$

The same result can (as we should expect) be obtained from (37), if we write $w_{A''} = w_A\lambda^{-1}$, etc.

Thus we see that a "normal" distribution of terminal displacements implies an exactly similar distribution of longitudinal forces on the terminal bulkheads. When, for example, the displacements of the left end bulkhead are given by (4), or (in the notation of § 22) by

$$w = S_n, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (i)$$

the displacements of the right end bulkhead (for a tube of β bays) will be given by

$$\bar{w} = S_n\,(\lambda_n)^\beta, \quad . \quad . \quad . \quad . \quad . \quad . \quad (ii)$$

the longitudinal forces on the left end bulkhead will be given by

$$\left.\begin{aligned} Z &= \chi_n \,.\, S_n \\ \chi_n &= L^2\Omega_D\,(k + 2)\,(\lambda_n^2 - 1)/(\lambda_n^2 + 1) \end{aligned}\right\} \quad . \quad . \quad . \quad (39)$$

where

and the longitudinal forces on the right end bulkhead will be given by

$$\bar{Z} = \chi_n \,.\, S_n\,(\lambda_n)^\beta \quad . \quad . \quad . \quad . \quad (40)$$

It must, however, be observed that when λ_n is replaced by its reciprocal (as will happen if we are discussing the associated normal system, in which the displacements fall off in the other direction), equation (39) gives a value for χ_n which is equal in magnitude but *opposite in sign*. So when

$$w = S_n \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i) } bis$$

and

$$w = S_n (\lambda_n)^{-\beta} \quad . \quad . \quad . \quad . \quad . \quad \text{(iii)}$$

we have for the forces

$$Z = -\chi_n \cdot S_n \quad . \quad . \quad . \quad . \quad . \quad (41)$$

and

$$\bar{Z}_n = -\chi_n \cdot S_n (\lambda_n)^{-\beta} \quad . \quad . \quad . \quad . \quad (42)$$

in place of (39) and (40), *where* χ_n *is given by* (39) *as before*.

40. Let us now suppose that the forces (*taken as positive when they tend to stretch the tube*) are specified for either end and analysed (by the methods of Section VI) into series as follows:—

$$\left.\begin{aligned} Z &= F_1 \cdot S_1 + F_2 \cdot S_2 + \ldots + F_n \cdot S_n + \ldots \\ &\quad + G_0 \cdot C_0 + G_1 \cdot C_1 + \ldots + G_n \cdot C_n + \ldots \\ \bar{Z} &= \bar{F}_1 \cdot S_1 + F_2 \cdot S_2 + \ldots + \bar{F}_n \cdot S_n + \ldots \\ &\quad + G_0 \cdot C_0 + G_1 \cdot C_1 + \ldots + \bar{G}_n \cdot C_n + \ldots \end{aligned}\right\} \quad . \quad . \quad . \quad (43)$$

(It will be noticed that C_0 has the same coefficient in either series. This is obviously necessary for equilibrium.)

We may assume (as in §34) that the displacement of type S_n (say) consists of a part of amplitude P_n at the left hand section, characterised by a decay factor λ_n; and of a part of amplitude Q_n at the left hand section, characterised by a decay factor λ_n^{-1}. Then from the results of §39 we may deduce that the terminal forces involved by the first component have an amplitude $\chi_n \cdot P_n$ at the left end section and an amplitude $\chi_n \cdot P_n (\lambda_n)^{\beta}$ at the right end section; and that the forces involved by the second component have an amplitude $-\chi_n \cdot Q_n$ at the left end section and $-\chi_n \cdot Q_n (\lambda_n)^{-\beta}$ at the right end section. Therefore P_n and Q_n can be deduced from the equations

$$\left.\begin{aligned} \chi_n (P_n - Q_n) &= F_n \\ \chi_n \{ P_n (\lambda_n)^{\beta} - Q_n (\lambda_n)^{-\beta} \} &= \bar{F}_n \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (44)$$

where χ_n is given by (39).

The coefficients of type G_n may be treated similarly, with the exception of G_0. The mode of displacement which is associated with this coefficient needs no discussion here, since the stresses are propagated without change.

41. *Illustrative Example.*—In illustration of the foregoing discussion, calculations have been carried out for the tube already described in §36. The longitudinal forces which we there found, as the result of our analysis, to be imposed on the joints of the terminal bulkheads are now taken as data (*cf.* Fig. 7) for the converse problem. We require to find the complete system of displacements.

The first step is to evaluate the coefficients which appear in the two series (43). The calculations, partially reproduced in Table VI, are exactly analogous to those described in connection with Table I.

In Table VII, columns (2) and (3) summarise the results, by giving values of F_n, $\bar{F}_n$, G_n, $\bar{G}_n$, for the values of n which are stated in column (1).

Columns (4) and (5) give the values of λ_n and λ_n^{-1} which correspond with these values of n.

Column (6) gives the corresponding values of $1/\chi_n$ as determined from (39).

Columns (7) and (8) show the values of P_n and Q_n as deduced from relations (44). It will be seen that these numerical values agree closely (as they should) with the values of P_n and Q_n already obtained in the earlier example and given in Table II.

The coefficients of types A and B, $\overline{A}$ and $\overline{B}$, shown in columns (9) and (10), are then deduced from relations (33).

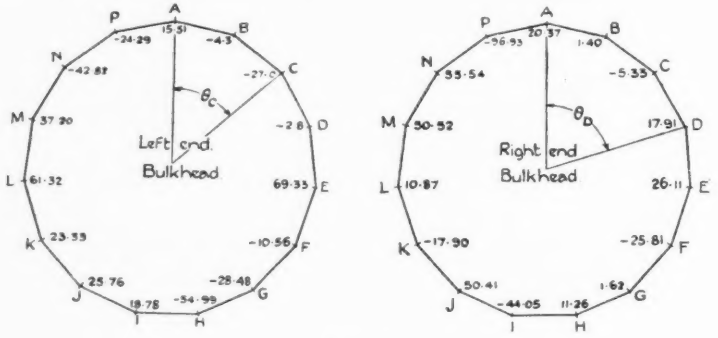


FIG. 7.

TABLE VI

Determination of Coefficients in the Series (43).

(1) Joint	(2) Specified Force Z	(3) Angular Position θ	(4) Displacement in System S_1 $(=\sin\theta)$	(5) Product of (2) and (4)	(6) Displacement in System S_2 $(=\sin 2\theta)$	(7) Product of (2) and (6)
A	15.51	0	0	0	0	0
B	−4.30	24	0.4067	−1.7488	0.7431	−3.1953
C	−27.00	48	0.7431	−20.0637	0.9945	−26.8515
D	−2.80	72	0.9510	−2.6628	0.5878	−1.6458
E	69.33	96	0.9945	68.9487	−0.2079	−14.4137
F	−10.56	120	0.8660	−9.1450	−0.8660	9.1450
G	−28.48	144	0.5878	−16.7405	−0.9510	27.0845
H	−54.99	168	0.2079	−11.4324	−0.4067	22.3644
I	18.78	192	−0.2079	−3.9044	0.4067	7.6378
J	25.76	216	−0.5878	−15.1417	0.9510	24.4978
K	23.33	240	−0.8660	−20.2038	0.8660	20.2038
L	61.32	264	−0.9945	−60.9827	0.2079	12.7484
M	37.20	288	−0.9510	−35.3772	−0.5878	−21.8662
N	−42.82	312	−0.7431	31.8195	−0.9945	42.5845
P	−24.29	336	−0.4067	9.8787	−0.7431	18.0499
Sum	55.99			−86.7561		116.3436
	÷15			÷7.5		÷7.5
	$=3.7327$			$=-11.5675$		$=15.5125$
	$=G_0$			$=F_1$		$=F_2$

It will be appreciated that in the present case the value of B_0 is indeterminate. This quantity merely represents a shift of the tube as a whole, which does not of course affect the stresses. We have, however, the relationship.

$$\overline{B}_0 = B_0 + G_0\beta/(k+2)\,L^2\Omega_D, \qquad (45)$$

which enables us to determine $\overline{B}_0$ when B_0 is assumed. If we take $B_0=0$, instead of $B_0=0.8667$ as in the earlier example, the displacements finally deduced will be as in Table IV, except that *every* displacement will be diminished (algebraically) by an amount 0.8667.

TABLE VII.

(1) Suffix	(2) Left End Bulkhead	(3) Right End Bulkhead	(4) (For $k=10$)	(5) (For $L^2\Omega_D=1$)	(6)	(7)	(8)	(9) Left End Bulkhead	(10) Right End Bulkhead
n	F_n	$\bar{F}_n$	λ_n	λ_n^{-1}	χ_n^{-1}	P_n	Q_n	A_n	$\bar{A}_n$
1	−11.5675	−6.0169	1.1861	0.8431	0.4930	−0.3787	5.3241	4.945	0.857
2	15.5125	2.7936	1.4051	0.7117	0.2544	0.0262	−3.9202	−3.894	−0.308
3	−6.7654	6.4692	1.6568	0.6036	0.1791	0.0588	1.2707	1.329	1.278
4	15.3654	17.1176	1.9342	0.5170	0.1441	0.0463	−2.1679	−2.112	2.383
5	−3.1984	27.4418	2.2152	0.4514	0.1260	0.0293	0.4323	0.462	3.466
6	−1.0373	−0.7418	2.4560	0.4072	0.1164	−0.000393	0.1204	0.120	−0.0857
7	−11.0497	14.5681	2.5988	0.3848	0.1123	0.00532	1.2462	1.252	1.643
	G_n	$\bar{G}_n$						B_n	$\bar{B}_n$
0	3.7327	3.7327						B_0	$B_0+1.866$
1	−3.8819	−0.5581	1.1861	0.8431	0.4930	0.1699	2.0837	2.254	1.221
2	−25.6327	−17.6451	1.4051	0.7117	0.2544	−0.4813	6.0397	5.558	2.919
3	15.5900	−12.6420	1.6568	0.6036	0.1791	−0.1163	−2.9019	−2.786	2.546
4	25.1139	−0.8002	1.9342	0.5170	0.1441	−0.00352	−3.6224	−3.626	−0.253
5	5.7053	24.4327	2.2152	0.4514	0.1260	0.02600	−0.6929	−0.667	3.067
6	−9.8962	1.1287	2.4560	0.4072	0.1164	0.000622	1.1530	1.154	0.142
7	4.7800	22.7152	2.5988	0.3848	0.1123	0.008271	−0.5285	−0.520	2.546

The determination of the coefficients of types A and B for the intermediate bulkheads, and the evaluation of the displacements for all the joints, then proceeds as already described in §36.

Section X.

Primary Stress Determination for a Tube having any Number of Bays, when the Longitudinal Forces are Specified for One Terminal Bulkhead, and the Displacements for the Other

42. The procedure required for this case can be described very briefly, in the light of the results obtained in Section IX. Taking as the left hand end bulkhead that for which the *forces* are specified, we assume that the data have been analysed by the methods of Section VI, and are expressed by the equations

$$\left.\begin{aligned} Z = F_1 . S_1 + F_2 . S_2 + \ldots + F_n . S_n + \ldots \\ + G_0 . C_0 + G_1 . C_1 + \ldots + G_n . C_n + \ldots \\ w = \bar{A}_1 . S_1 + \bar{A}_2 . S_2 + \ldots \quad + \bar{A}_n . S_n + \ldots \\ + \bar{B}_0 . C_0 + \bar{B}_1 . C_1 + \ldots + \bar{B}_n . C_n + \ldots \end{aligned}\right\} \quad . \quad . \quad (46)$$

Then the displacement of type S_n may be analysed into two parts as before; and giving P_n and Q_n the same significance as before, we may deduce their values from the equations

$$\left.\begin{aligned} \chi_n (P_n - Q_n) = F_n \\ P_n (\lambda_n)^\beta + Q_n (\lambda_n)^{-\beta} = \bar{A}_n \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (47)$$

Exactly similar treatment serves to determine the displacement systems of type C_n, excepting C_0, which as before raises special considerations.

In this case, however, the amplitudes are perfectly definite. B_0 is determined from the analysis of the displacement at the left hand end, G_0 from the analysis of the forces acting on the right hand end; B_0 can then be deduced from (45).

The calculation then proceeds as before.

Section XI.

One Terminal Section Free: Forces or Displacements Specified for the Other

43. At the free section the forces are all zero. Hence this is a particular case of IX or of X, according as the forces or the displacements are specified at the other terminal section.

(*a*) *If the forces are specified,* we may regard the problem as a particular case of IX. Taking the free end as the *left* hand terminal section, we have in (43) of §40

$$F_1 = F_2 = \ldots = G_0 = G_1 = \ldots = 0 \quad . \quad . \quad . \quad . \quad (i)$$

and the values of $\bar{F}_1, \bar{F}_2, \ldots \bar{G}_1, \bar{G}_2, \ldots$ may be deduced from the data for the loaded end, exactly as before.

It follows that the first of (44) is here replaced by

$$P_n - Q_n = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (ii)$$

whence the second of (44) is replaced by

$$P_n = Q_n = \bar{F}_n / \chi_n \{ (\lambda_n)^\beta - (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad (48)$$

Similarly, taking the free end as the *right* hand terminal section, we have in (43) of §40

$$\bar{F}_1 = \bar{F}_2 = \ldots = G_0 = \bar{G}_1 = \ldots = 0 \quad . \quad . \quad . \quad . \quad (iii)$$

and the values of $F_1, F_2, \ldots G_1, G_2$ may be deduced from the data as before.

It follows that the second of (44) is replaced by

$$P_n(\lambda_n)^\beta - Q_n(\lambda_n)^{-\beta} = 0 \quad . \quad . \quad . \quad . \quad \text{(iv)}$$

whence the first of (44) is replaced by

$$P_n(\lambda_n)^\beta = Q_n(\lambda_n)^{-\beta} = -F_n/\chi_n \{ (\lambda_n)^\beta - (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad (49)$$

(*b*) *If the displacements are specified*, we have a particular case of X.

If we take the free end as the *left* hand terminal section, the first of (46) is replaced by (i), and the first of (47) by (ii); so the second of (47) is replaced by

$$P_n = Q_n = A_n/\{ (\lambda_n)^\beta + (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad . \quad (50)$$

Thus the two components have the same amplitude ($P_n = Q_n$) at the free end, and this amplitude is related with the specified displacement at the other end by equation (50). Also at the right hand end the two components have amplitudes $P_n(\lambda_n)^\beta$ and $Q_n(\lambda_n)^{-\beta}$ respectively. Therefore when the *right* hand end is free and the displacements are specified for the left hand end, equation (50) will be replaced by

$$P_n(\lambda_n)^\beta = Q_n(\lambda_n)^{-\beta} = A_n/\{ (\lambda_n)^\beta + (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad (51)$$

Section XII.

One Terminal Section Fixed: Forces or Displacements Specified for the Other

44. This problem, again, may be briefly dismissed, since it constitutes a particular example of either VII or X. At the fixed end all the displacements are zero.

(*a*) *If the displacements are specified*, we have an example of problem VII. Taking the fixed end as the *left* hand terminal section, we have in (24) of §30

$$A_1 = A_2 = \ldots = B_0 = B_1 = \ldots = 0 \quad . \quad . \quad . \quad . \quad \text{(i)}$$

whence the first of (33) is replaced by

$$P_n + Q_n = 0 \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

and the second of (33) by

$$P_n = -Q_n = \bar{A}_n/\{ (\lambda_n)^\beta - (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad (52)$$

Similarly, taking the fixed end as the *right* hand terminal section, we have in (32) of §34

$$\bar{A}_1 = \bar{A}_2 = \ldots = \bar{B}_0 = \bar{B}_1 = \ldots = 0 \quad . \quad . \quad . \quad . \quad \text{(iii)}$$

whence the second of (33) is replaced by

$$P_n(\lambda_n)^\beta + Q_n(\lambda_n)^{-\beta} = 0 \quad . \quad . \quad . \quad . \quad \text{(iv)}$$

and the first of (33) by

$$P_n(\lambda_n)^\beta = -Q_n(\lambda_n)^{-\beta} = -A_n/\{ (\lambda_n)^\beta - (\lambda_n)^{-\beta} \} \quad . \quad . \quad (53)$$

(*b*) *If the forces are specified*, we have an example of problem X. If we take the *right* hand end as fixed, so that the forces are specified for the left hand end, the second of (46) is replaced by (iii), and the second of (47) by (iv). Hence we derive, in place of the first of equations (47),

$$P_n(\lambda_n)^\beta = -Q_n(\lambda_n)^{-\beta} = F_n/\chi_n \{ (\lambda_n)^\beta + (\lambda_n)^{-\beta} \} \quad . \quad . \quad (54)$$

Thus the two components have equal but opposite amplitudes at the fixed end, and these amplitudes are related by equation (54) with the specified forces at the other end. It follows that when the *left* hand section is fixed equation (54) will be replaced by

$$P_n = -Q_n = \bar{F}_n/\chi_n \{ (\lambda_n)^\beta + (\lambda_n)^{-\beta} \} \quad . \quad . \quad . \quad (55)$$

45. It is of interest to compare the effects of a free and of a fixed end. Thus equation (48) for a free-ended tube compares with equation (55) for a fixed-ended tube, and equation (49), similarly, with (54); equation (50) for the free-ended tube corresponds with equation (52) for the fixed-ended tube, and equation (51), similarly, with (53).

Section XIII.

Forces applied to the Joints of an Intermediate Section: Terminal Sections either Free or Fixed

46. It will not be necessary to discuss in detail more than one of these cases, because the modifications demanded by the others will be obvious. Accordingly we proceed to discuss the case in which *both end sections are free*.

Consider a tube of $(\beta_1+\beta_2)$ bays, in which β_1 bays separate the left hand end from the loaded section and β_2 bays separate the loaded section from the right hand end.

We may imagine that the forces at the loaded section have been analysed into a series of the type

$$Z=F_1 \,.\, S_1+F_2 \,.\, S_2+\ldots+F_n \,.\, S_n+\ldots \\ +G_0 \,.\, C_0+G_1 \,.\, C_1+\ldots+G_n \,.\, C_n+\ldots \quad . \quad . \quad . \quad (56)$$

(*the coefficient G_0 being necessarily zero, in this problem, because otherwise the applied forces would not be a system in equilibrium*). We now proceed to examine the effects of the component of type S_n: evidently, if these can be determined, the effects of the complete system may be obtained by a synthesis of similar solutions.

47. Of the total applied force system $F_n \,.\, S_n$, part will be resisted by the portion of the tube to the left of the loaded section, and part by the portion on the right. *We assume that each portion resists a part which is also of the type* S_n; that is, we assume that the left hand portion resists a force system $(F_n)_L \,.\, S_n$, and the right hand portion a force system $(F_n)_R \,.\, S_n$, where

$$(F_n)_L-(F_n)_R=F_n \quad . \quad . \quad . \quad . \quad . \quad (57)$$

The negative sign in (57) is necessitated by our convention that forces are to be taken as positive when they tend to stretch the portion on which they act. For if Z, in (56), acts in the direction of z increasing, it will tend to stretch the left hand, and to compress the right hand portion of the tube.

48. Now consider the effect of $(F_n)_L \,.\, S_n$ acting on the left hand portion. On the assumptions stated, this portion may be regarded as a tube of β_1 bays, loaded at the right hand terminal section and free at the other. So we have the first case of problem XI (*a*); and the displacement at the right hand (*i.e.*, the loaded) end will be

$$A_n \,.\, S_n=\{\, P_n\,(\lambda_n)^{\beta_1}+Q_n\,(\lambda_n)^{-\beta_1}\,\}\,S_n \quad . \quad . \quad . \quad (58)$$

where, by (48) of §43,

$$P_n=Q_n=(F_n)_L/\chi_n\,\{\,(\lambda_n)^{\beta_1}-(\lambda_n)^{-\beta_1}\,\} \quad . \quad . \quad . \quad (59)$$

A positive value for the displacement (58) will indicate a displacement in the direction of z increasing.

The right hand portion may be treated similarly, since it is an example of the second case of XI (*a*). The displacement at the loaded end will now be given by

$$A'_n \,.\, S_n=(P'_n+Q'_n)\,S_n \quad . \quad . \quad . \quad . \quad . \quad (60)$$

where, by (49),

$$P'_n\,(\lambda_n)^{\beta_2}=Q'_n\,(\lambda_n)^{-\beta_2}=-(F_n)_R/\chi_n\,\{\,(\lambda_n)^{\beta_2}-(\lambda_n)^{-\beta_2}\,\} \quad . \quad . \quad (61)$$

Here again a positive value for the displacement indicates a displacement in the direction of z increasing.

Therefore the condition that the two portions of our tube shall continue to fit together after strain is

$$A_n=A'_n,$$

or

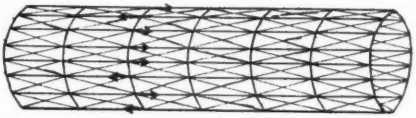
$$\{\, P_n\,(\lambda_n)^{\beta_1}+Q_n\,(\lambda_n)^{-\beta_1}\,\}=P'_n+Q'_n \quad . \quad . \quad . \quad (i)$$

If we substitute from (59) and (61), the condition may be written in the form

$$(F_n)_L \{ (\lambda_n)^{\beta_1} + (\lambda_n)^{-\beta_1} \} / \{ (\lambda_n)^{\beta_1} - (\lambda_n)^{-\beta_1} \} + (F_n)_R \{ (\lambda_n)^{\beta_2} + (\lambda_n)^{-\beta_2} \} / \{ (\lambda_n)^{\beta_2} - (\lambda_n)^{-\beta_2} \} = 0 \quad . \quad . \quad (62)$$

Equation (62), taken in conjunction with (57), enables $(F_n)_L$ and $(F_n)_R$ to be calculated. *Thus our assumption is justified by its result*, and the solution can be completed.

49. In illustration of the foregoing paragraphs, the structure already considered (with fifteen sides and six bays) has been stressed under conditions in which the terminal sections are regarded as free, and a system of horizontal loads are applied at the second intermediate bulkhead. The conditions are illustrated in Fig. 8.



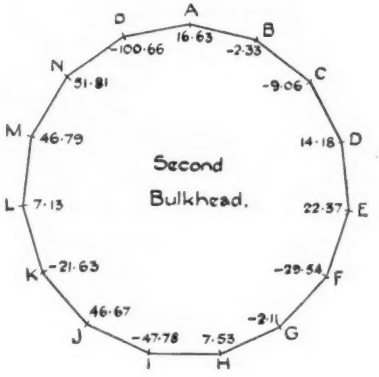


FIG. 8.

The loads are first analysed into " normal " components as described in Section VI, and values of $(F_n)_L$ and $(F_n)_R$ are obtained from equations (57) and (62); Table VIII, columns (1) to (10), show the general method of computation. Equations (59) and (61) then yield values for P_n, Q_n, P'_n, Q'_n; and the amplitudes of the component displacements at the different bulkheads can be derived from equation (34), as shown in Table VIII, columns (11) to (23). Finally, the total displacements, and the proportion of the loads taken by each part of the structure, are obtained by methods already described in §36 in connection with Table III. The results are shown in Table IX.

50. It may be remarked that the treatment of the foregoing (or of any other case of problem XIII) can be extended without difficulty to allow for a difference in stiffness between the left and right hand portions of the tube. *It is however essential that the change in stiffness shall occur at the section where the forces are applied*: therefore it is only in the case of a uniform tube that our solution can be used to derive, by synthesis, a solution for any loading whatsoever.

Evidently such synthesis is possible if we extend our analysis (as is not difficult to do) to the case of a tube which changes its elasticity at one section and is loaded at another. It is in fact easy to contemplate any number of other problems which might be treated on the lines of this paper; but it has been thought best, in order to avoid undue length, to confine attention to problems of the more obvious types treated in sections VII to XIII.

TABLE VIII.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Suffix n	Second Bulkhead F_n	μ	(For $K=10$) λ	$\lambda^2+\lambda^{-2}$	$\lambda^2-\lambda^{-2}$	$\lambda^4+\lambda^{-4}$	$\lambda^4-\lambda^{-4}$	$(2)\Big/\left\{1+\frac{(5).(8)}{(6).(7)}\right\}$ $(F_n)_L$	$(F_n)_L-F_n$ $(F_n)_R$
1	−6.0169	−1.8270	1.1861	2.1176	0.6960	2.4845	1.4739	−2.1451	3.8718
2	2.7936	−1.3382	1.4051	2.4807	1.4678	4.1544	3.6414	1.1258	−1.6678
3	6.4692	−0.6180	1.6568	3.1093	2.3807	7.6676	7.4022	2.8615	−3.6077
4	17.1176	0.2090	1.9342	4.0084	3.4738	14.0674	13.9246	7.9907	−9.1269
5	27.4418	1.0000	2.2152	5.1109	4.7033	24.1212	24.0382	13.1748	−14.2670
6	−0.7418	1.6180	2.4560	6.1977	5.8661	36.4117	36.3567	−0.3610	0.3808
7	14.5681	1.9562	2.5988	6.9019	6.6057	45.6352	45.5914	7.1280	−7.4401
	G_n							$(G_n)_L$	$(G_n)_R$
0	0	−2.0000	1.0000					0	0
1	−0.5581	−1.8270	1.1861					−0.1990	0.3591
2	−17.6451	−1.3382	1.4051					−7.1109	10.5342
3	−12.6420	−0.6180	1.6568					−5.5918	7.0502
4	−0.8002	0.2090	1.9342					−0.3735	0.4267
5	24.4327	1.0000	2.2152					11.7301	−12.7026
6	1.1287	1.6180	2.4560					0.5493	−0.5794
7	22.7152	1.9562	2.5988					11.1142	−11.6010

TABLE VIII (*continued*).

(11) (For $L^2\Omega_D=1$)	(12) (9),(11) / (6)	(13) (12).2 Left End	(14)	(15) (12).(14) First Bulkhead	(16) (12).(5) Second Bulkhead	(17) (10).(11) / (5)	(18) (17).(7) Second Bulkhead	(19)	(20) (17).(19) Third Bulkhead	(21) (17).(5) Fourth Bulkhead	(22) (17).(14) Fifth Bulkhead	(23) (17).2 Right End
χ^{-1}	$P_n=Q_n$	A_n	$\lambda+\lambda^{-1}$	A_n	$\overline{A}_n$	$P'_n\lambda^4=Q'_n\lambda^{-4}$	A'_n	$\lambda^3+\lambda^{-3}$	A_n	A_n	A_n	A_n
0.4930	−1.5194	−3.0389	2.0292	−3.0833	−3.2176	−1.2951	−3.2176	2.2679	−2.9371	−2.7424	−2.6280	−2.5901
0.2544	0.1951	0.3902	2.1168	0.4130	0.4840	0.1165	0.4841	3.1346	0.3654	0.2891	0.2466	0.2330
0.1791	0.2153	0.4305	2.2604	0.4866	0.6693	0.0873	0.6693	4.7678	0.4162	0.2714	0.1973	0.1746
0.1441	0.3315	0.6629	2.4512	0.8125	1.3287	0.0944	1.3287	7.3743	0.6965	0.3786	0.2315	0.1889
0.1260	0.3530	0.7059	2.6666	0.9412	1.8039	0.0748	1.8038	10.9622	0.8198	0.3822	0.1994	0.1496
0.1164	−0.0072	−0.0143	2.8632	−0.0205	−0.0444	−0.0012	−0.0444	14.8819	−0.0181	−0.0075	−0.0035	−0.0024
0.1123	0.1212	0.2424	2.9836	0.3615	0.8364	0.0183	0.8363	17.6087	0.3227	0.1265	0.0547	0.0366
		B_n		B_n	$\overline{B}_n$		B'_n		B_n	B_n	B_n	B_n
	0	0		0	0	0	0		0	0	0	0
0.4930	−0.1410	−0.2820		−0.2861	−0.2985	−0.1201	−0.2984		−0.2724	−0.2543	−0.2437	−0.2402
0.2544	−1.2325	−2.4649		−2.6089	−3.0574	−0.7360	−3.0575		−2.3071	−1.8257	−1.5579	−1.4719
0.1791	−0.4207	−0.8413		−0.9509	−1.3080	−0.1706	−1.3079		−0.8133	−0.5304	−0.3856	−0.3412
0.1441	−0.0155	−0.0310		−0.0380	−0.0621	−0.0044	−0.0621		−0.0326	−0.0177	−0.0108	−0.0088
0.1260	0.3143	0.6285		0.8380	1.6061	0.0666	1.6061		0.7299	0.3403	0.1775	0.1332
0.1164	0.0109	0.0218		0.0312	0.0675	0.0018	0.0675		0.0276	0.0115	0.0053	0.0037
0.1123	0.1890	0.3779		0.5637	1.3041	0.0286	1.3040		0.5032	0.1972	0.0853	0.0572

TABLE IX.

Joint	Loads applied at second bulkhead	Loads taken by left part	Loads taken by right part	Displacements at Bulkheads						
				Left End	First	Second	Third	Fourth	Fifth	Right End
A	16.63	10.12	−6.51	−2.591	−2.451	−1.748	−2.165	−2.079	−1.930	−1.868
B	−2.33	−0.50	1.83	−2.089	−2.090	−2.130	−1.988	−1.901	−1.845	−1.825
C	−9.06	−4.46	4.61	−1.634	−1.713	−2.005	−1.691	−1.564	−1.519	−1.507
D	14.18	6.20	−7.99	−0.508	−0.384	0.009	−0.552	−0.884	−1.058	−1.111
E	22.37	10.52	−11.85	−0.730	−0.540	0.146	−0.675	−1.065	−1.240	−1.290
F	−29.54	−13.77	15.77	−2.731	−2.980	−3.879	−2.783	−2.257	−2.020	−1.951
G	−2.11	−0.04	2.07	−2.417	−2.427	−2.420	−2.259	−2.092	−1.977	−1.936
H	7.53	4.80	−2.73	−1.827	−1.761	−1.427	−1.598	−1.535	−1.448	−1.414
I	−47.78	−22.57	25.21	−1.499	−1.895	−3.379	−1.630	−0.843	−0.504	−0.408
J	46.67	22.56	−24.12	2.336	2.725	4.215	2.551	1.860	1.587	1.514
K	−21.63	−11.47	10.16	2.863	2.672	1.906	2.591	2.780	2.809	2.807
L	7.13	1.55	−5.58	4.877	4.912	5.006	4.582	4.235	4.008	3.930
M	46.79	19.82	−26.97	6.323	6.726	7.975	6.074	4.897	4.265	4.067
N	51.81	24.38	−27.42	3.269	3.699	5.300	3.395	2.525	2.145	2.036
P	−100.66	−47.12	53.53	−3.641	−4.494	−7.568	−3.852	−2.075	−1.274	−1.044

Appendix I.

Calculation of the Decay Factor λ

Equation (14), which relates the decay factor with the quantity denoted by μ, has been thrown into the equivalent form[19]

$$\lambda^2 - 2s\lambda + 1 = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i)}$$

where

$$s = (k+2)/(k-\mu_n) \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

k is a specified parameter of the framework, and it is assumed that the value for μ_n has been determined, appropriate to the normal distribution which is under consideration.

From equation (i) the values of λ and λ^{-1} which are associated with a known value of μ_n can be determined in a form appropriate for numerical calculation. We have

$$\left.\begin{aligned} \lambda &= s + \sqrt{(s^2-1)} \\ \lambda^{-1} &= s - \sqrt{(s^2-1)} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad \text{(iii)}$$

where s is known from (ii). Since, in relation to a tube of many bays, λ and its reciprocal occur raised to a high power,[20] considerable accuracy is necessary, and seven figure logarithms should be used in computation.

We observe that, if $k > 2$, λ will always be positive; for we have seen (§20) that $\mu \not> 2$. On the other hand, negative values of λ can occur when k has a value less than 2: in the corresponding type of displacement, the stresses in adjoining bays will be similarly distributed but opposite in sign.

In particular, when $k < 2$ it is possible for k and μ to have equal values. In a case of this kind, as may be seen either from (iii) or directly from the original equation (14), λ can be zero and its reciprocal infinite; and in the corresponding type of displacement, the stresses in one bay will *not* be propagated into the bay adjoining.

Appendix II.

The Roots of the Determinantal Equation (15) in μ

1. We write equation (15) in the form

$$\Delta_N = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i)}$$

so that

$$\Delta_N = \begin{vmatrix} \mu, & 1, & 0, & 0, & \ldots\ldots\ldots, & 1 \\ 1, & \mu, & 1, & 0, & \ldots\ldots\ldots, & 0 \\ 0, & 1, & \mu, & 1, & \ldots\ldots\ldots, & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots\ldots\ldots & \ldots \\ 0, & 0, & 0, & 0, & \ldots, & 1, \ \mu, \ 1 \\ 1, & 0, & 0, & 0, & \ldots, & 0, \ 1, \ \mu \end{vmatrix} \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

and we form a new first column by adding to each element of the old first column the corresponding elements of the second, third, . . . Nth column multiplied by $e^{i\phi}$, $e^{2i\phi}$, . . . $e^{(N-1)\,i\phi}$, respectively. By a known theorem, the value of the determinant is unaffected; and the elements of the new first column are

$$\left.\begin{aligned} \mu + e^{i\phi} + e^{(N-1)\,i\phi} &= (\mu + 2\cos\phi) + e^{-i\phi}\,(e^{Ni\phi} - 1), \\ 1 + \mu e^{i\phi} + e^{2i\phi} &= (\mu + 2\cos\phi)\, e^{i\phi}, \\ e^{i\phi} + \mu e^{2i\phi} + e^{3i\phi} &= (\mu + 2\cos\phi)\, e^{2i\phi}, \\ \ldots\ldots\ldots\

Thus we see that $(\mu+2\cos\phi)$ is a factor of every element of the new first column except the first and last; and it will be a factor of these elements too if

$$e^{Ni\phi}-1=0$$

—that is, if

$N\phi$ is zero, or an integral multiple of 2π. . . . . (iv)

2. When the condition (iv) is satisfied, we may derive from (ii) the expression

$$\Delta_N=(\mu+2\cos\phi)\begin{vmatrix} 1, & 1, & 0, & \dots, & 0, & 1 \\ e^{i\phi}, & \mu, & 1, & \dots, & 0, & 0 \\ e^{2i\phi}, & 1, & \mu, & \dots, & 0, & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ e^{(N-1)\,i\phi}, & 0, & 0, & \dots, & 1, & \mu \end{vmatrix} \quad . \quad . \quad . \quad . \quad (v)$$

We treat the new determinant in similar fashion, forming a new first row by addition to the old first row of the second, third, . . . Nth rows multiplied by $e^{i\phi}, e^{2i\phi}, \dots, e^{(N-1)\,i\phi}$ respectively. The value of the determinant is unaltered; and since by hypothesis (iv) is satisfied, *all* terms in the new first row now contain $(\mu+2\cos\phi)$ as a factor, excepting the first which is

$$\begin{aligned} &1+e^{2i\phi}+e^{4i\phi}+\dots+e^{2\,(N-1)\,i\phi} \\ &=1+\cos 2\phi+\cos 4\phi+\dots+\cos 2\,(N-1)\,\phi \\ &\quad+i\{\sin 2\phi+\sin 4\phi+\dots+\sin 2\,(N-1)\,\phi\} \\ &=(\sin N\phi/\sin\phi)\,e^{i\,(N-1)\,\phi} \end{aligned}$$

by known trigonometrical formulæ. This expression shows that the first term of the new first row will vanish, in virtue of (iv), unless $\sin\phi$ is zero, in which case it reduces to the series

$$1+\cos 2\phi+\cos 4\phi+\dots \text{ to } N \text{ terms.}$$

Evidently this series will not vanish if ϕ is zero or an even multiple of π; but it *will* vanish if

(*a*) N is even,

and (*b*) 2ϕ is an odd multiple of π.

If it vanishes, then $(\mu+2\cos\phi)$ is a factor of every term in the new first row, and therefore of the determinant in (v); accordingly $(\mu+2\cos\phi)^2$ is a factor of Δ_N. The double condition which must be satisfied may be written in the form

$$\left.\begin{array}{l} N\phi \text{ is an integral (not zero) multiple of } 2\pi \\ 2\phi \text{ is an } \textit{odd} \text{ integral multiple of } \pi \end{array}\right\} \quad . \quad . \quad (vi)$$

3. We have now to consider what factors of Δ_N have been determined by the foregoing investigation. Evidently (iv) permits ϕ to have the value 0, so that $(\mu+2)$ is a factor of Δ_N; but the condition (vi) is not satisfied, and hence this factor is not repeated. Additional factors, *all different and all repeated,* will be obtained if we write

$$\begin{aligned} \phi&=(2\pi/N)\times[1,\ 2,\ \dots,\ \tfrac{1}{2}(N-1)], \text{ when } N \text{ is odd,} \\ \phi&=(2\pi/N)\times[1,\ 2,\ \dots,\ (\tfrac{1}{2}N-1)], \text{ when } N \text{ is even,} \end{aligned}$$

and when N is even an additional factor (*not* repeated, since the condition (vi) is not satisfied) is obtained by making ϕ equal to π.

Summarising, we may say that distinct factors are obtained by writing $\phi=n\,(2\pi/N)=n\alpha$ (say), and giving to n the values

$$\begin{aligned} &0,\ 1,\ 2,\ \dots,\ \tfrac{1}{2}(N-1), && \text{when } N \text{ is odd,} \\ &0,\ 1,\ 2,\ \dots,\ \tfrac{1}{2}N, && \text{when } N \text{ is even.} \end{aligned}$$

Moreover, all of these factors occur twice, except those corresponding to $n=0$ and $n=\frac{1}{2}N$. So in every case we have discovered N factors of Δ_N.

4. But Δ_N is evidently a polynomial in μ of the Nth degree, and accordingly will have N factors and no more. It follows that we have factorised Δ_N completely, since the index of μ^N is unity.

THE REFUELLING OF AIRCRAFT IN FLIGHT

BY

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The establishment of contact between aircraft in flight for the purpose of refuelling, has until recently been regarded as a somewhat hazardous procedure employed mainly during attempts to create endurance records.

It would appear, however, that if such contact between aircraft could be established safely and as a routine operation, considerable advantages could be obtained by the employment of such a scheme.

From the point of view of commercial aviation, not only would it make possible long distance non-stop flights over regular air routes, but it would enable a large increase in pay load to be carried, since the bulk of the aircraft's consumable load, *i.e.*, fuel, would not be taken on board until the aircraft had left the ground and climbed to a reasonable height.

This consumable load for reasons of the " take-off run " and climb is, in an aircraft of normal design, the main factor governing the useful load that can be carried (particularly so in flying boats), and at present an increase in the distance of a non-stop flight is obtainable only at the expense of useful load or the factors of safety.

Refuelling in the air has been successfully carried out in America and Germany, and from what has been made known, they appear, in those countries, to be encouraged by its possibilities in spite of the apparent risks entailed in the methods employed.

In America a " Curtis Robin " monoplane specially equipped has become a recognised " refueller " and has delivered fuel to other aircraft in flight successfully by day and night although, from the somewhat vague figures available, its rate of transfer of fuel appears to be comparatively low.

The rate at which fuel can be transferred is an important item if large aircraft are to be refuelled for long distance work, since the accuracy of flight which must be maintained during contact is apt to become a strain on the pilots if the period of contact is unduly prolonged.

It is considered, however, that with properly designed apparatus and tanks suitably prepared, it would be practicable to transfer fuel at the rate of 100 gallons per minute.

Recent experiments carried out at the Royal Aircraft Establishment, Farnborough, have shown that by employing a method which avoids fouling the airscrews and control surfaces of the receiving aircraft, contact between large aircraft for the purpose of refuelling in the air can be successfully established without entailing undue risks. Further, with practice and skilled personnel, once contact has been established the two aircraft are able to maintain their respective stations for a reasonable period, without great difficulty, it becoming easier the shorter the distance between the aircraft, within the limits of safety.

On the assumption then that the refuelling of aircraft in flight has been established as a practical proposition, its application to a hypothetical aircraft of the typical twenty-seater passenger type will be considered, where the engines, structure weight, wing loading, etc., are based on the average for a normal aircraft. Firstly,

considering the characteristics of the aircraft loaded in the normal manner, and secondly, considering what features would be altered by substituting pay load for fuel for taking-off purposes, adding the main fuel load in the air.

Assume that the aircraft has a total all-up weight of 20,000lbs., made up as follows :—

	Lbs.
Pay load (20 passengers and luggage at 200lbs. each)	= 4,000
Structure weight, passenger equipment, crew, etc. (47 per cent. approx. of total all-up weight)	= 9,450
Horse-power, 3 engines at 450 h.p. = 1,350 h.p.	
Fuel for say 5 hours' flight at consumption rate of 80 galls. per hour = 400 galls.	= 3,000
Oil, 25 galls.	= 250
Three engines and installations	= 3,000
Tanks and fixings	= 300
Total	= 20,000

Assume a wing loading of 10lbs./sq. ft., then

Wing area = 20,000/10 = 2,000 sq. ft.
Power loading = 20,000/1,350 = 14.8lbs./h.p.

The performance of this aircraft will be dealt with later.

Let it be considered now that this same aircraft is to be refuelled in the air immediately upon attaining, say, 1,000ft. For this purpose, sufficient fuel for half an hour's flying only (*i.e.*, 40 gallons), will be carried at the time of taking off, the pay load being increased by the difference in weight between 400 gallons and 40 gallons of fuel, *i.e.*, 2,700lbs. When in the air, however, the all-up weight of the aircraft will be increased by 2,700lbs., the weight of the fuel added, and if the original factors of safety are to be maintained the structure will require to be increased in strength for this overload. It will be assumed for the purpose of this aircraft that the increase in strength of structure is in proportion to the structural weight added, and that the weight due to structure only for such an aircraft is in the region of 37 per cent. of the total all-up weight.

In adapting the aircraft for refuelling, modifications involving an additional load in the region of 100lbs. might be found necessary. (This figure and the 37 per cent. previously mentioned are both generous estimates.)

The new all-up weight after refuelling will then be :—

$$W = 20,000 + 2,700 + 100 + (W - 20,000) .37$$
$$W - .37\ W = 22,800 - (20,000 \times .37)$$
$$W = 15,400/.63 = 24,400\text{lbs.}$$

Therefore the increase in structure weight

$$= 24,400 - 22,700 = 1,700\text{lbs.}$$

The new take-off weight = 20,000 + 1,700 = 21,700lbs.

Since this aircraft is based on normal design data and characteristics it should at an all-up weight of 20,000lbs. be within the requirements of the British Certificate of Airworthiness of the Normal Category. It will be necessary, however, to know the performance of the aircraft in order to see if at the new take-off weight, which shows an increase in pay load of 2,700lbs. or 67.5 per cent., it is still capable of complying with the requirements for take-off and climb, and further, whether under the maximum load conditions after refuelling in the air there is still sufficient power available for reasonable flying speed and climb.

For the purpose of compiling the necessary performance curves, four conditions of loading will be considered, *i.e.*,

Case I, all-up weight = 20,000lbs.
Case II, ,, = 22,000lbs.
Case III, ,, = 25,000lbs.
Case IV, ,, = 27,000lbs.

CASE I.

W = 20,000lbs. = all-up weight.
S = 2,000 sq. ft. = wing area.
w = 10lbs. sq. ft. = wing loading.
h.p. = $3 \times 450 = 1,350$.
$L = k_L \rho S V^2$ and is taken as equal to W for the purposes of this calculation.
$V^2 = L/k_L \rho S = w/k_L \rho = 10/(k_L \times .00238) = 4,200/k_L$.
$V = \sqrt{(4,200/k_L)}$.
$R = k_R \rho S V^2$ = drag of complete aircraft
$= W/(L/D) = 20,000/(L/D)$ since $L = W$.
L/D (or L/R) $= k_L \rho S V^2 / k_R \rho S V^2 = k_L/k_R$.
Assume efficiency of airscrews = .80 and h.p. available = $3 \times 450 \times .8 = 1,080$ h.p.
h.p. required = $R \times V$ ft./sec./550.

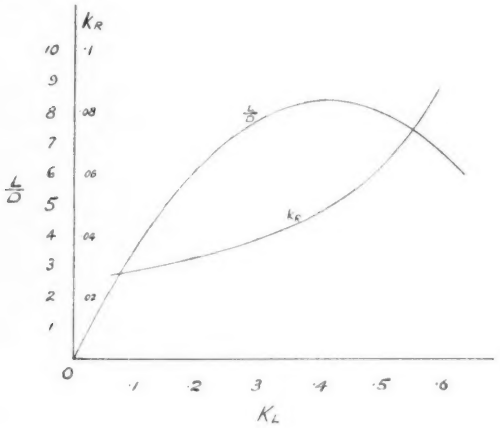


FIG. 1.

Then with reference to the curves, Fig. 1, which are typical for an aircraft with M. 12 section wing (approximating to R.A.F. 34) and are deduced from wind tunnel and full-scale tests, the following tables can be compiled:—

k_L	k_R	L/D	R lbs.	V^2	V ft. per sec.	H.P. required.	$\%V_1$	$\%$ H.P$_1$
.1	.0286	3.5	5720	42000	205	2135	127.4	197.5
.15	.0300	5.0	4000	28000	167.5	1217	104.0	112.6
.2	.0328	6.1	3280	21000	145	864	90.0	80.0
.3	.0390	7.7	2600	14000	118.5	560	73.5	51.9
.4	.0476	8.4	2440	10500	102.5	455	63.6	42.1
.5	.0625	8.0	2500	8400	91.6	416.3	56.9	38.5
.6	.0896	6.7	2985	7000	83.6	453.5	51.9	42.0

To obtain a value for best possible normal speed with an airscrew designed for that speed and giving an efficiency of .8, so that column " percentage V " may be compiled, V is plotted against h.p. required, curve Fig. 2.

From this curve it appears that the top speed will be in the region of 110 m.p.h., *i.e.*, the design speed may be taken as 161 ft./sec.

In Fig. 3 per cent. V is plotted against per cent. h.p., the effective h.p. curve being a typical effective power curve with a fixed pitch airscrew. Fig. 3 shows that the top speed when $W=20{,}000$ is 108.5 m.p.h. In considering W at 22,000, 25,000 and 27,000 the design speed will be taken as 107 m.p.h. =(157 ft./sec.), which would appear to be a speed approximating to the average for the loadings under consideration.

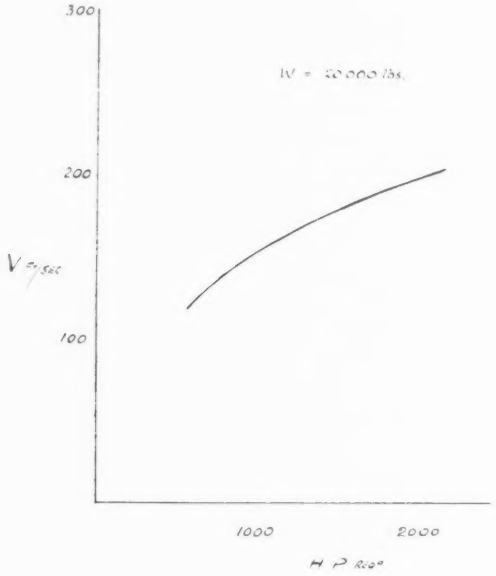


FIG. 2.

CASE II.

	% V_2	% H.P.$_2$
Taking $W=22{,}000$lbs.	137	—
$V_1=\sqrt{(20{,}000/\rho S k_L)}$ $V_2=\sqrt{(22{,}000/\rho S k_L)}$	112	130.2
$V_2=V_1\sqrt{(22{,}000/20{,}000)}=V_1$ 1.05.	96.8	92.5
	79	60.0
Considering the alteration in design speed per cent. V,	68.5	48.6
per cent. V_1 figures then should be increased by the factor	61.1	44.5
$1.05\times 161/157=1.075$.	55.8	48.5

Per cent. h.p., h.p.$_1$, should be increased by

$V\times 1.05$ and $R\times 22{,}000/20{,}000$ in the formula h.p. $=RV/550$
=the factor 1.154.

CASE III.

Taking $W = 25{,}000$.

Factor for increase of per cent. V over Case II
$= V_3 = V_2 \sqrt{(25{,}000/22{,}000)} = 1.065$.

Factor for increase of per cent. h.p. over Case II
$= V\ 1.065 \times R\ 25{,}000/22{,}000 = 1.21$.

% V_3	% H.P.$_3$
146	—
119.3	158
103	111.8
84.2	72.6
73	58.4
65	53.8
59.5	58.8

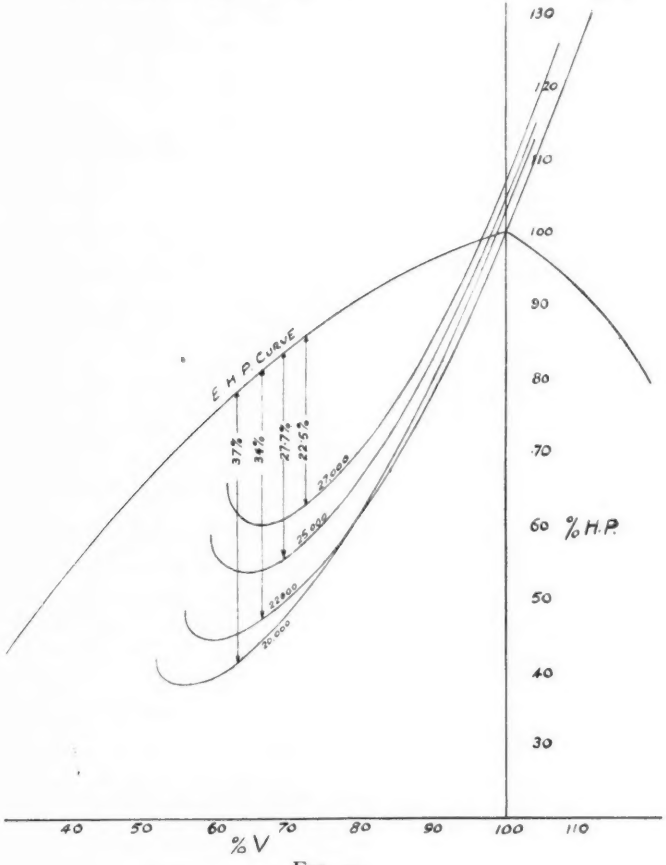


FIG. 3.

CASE IV.

Taking $W = 27{,}000$.

Factor for increase of per cent. V over Case II
$= V_4 = V_2 \sqrt{(27{,}000/22{,}000)} = 1.108$.

Factor for increase of per cent. h.p. over Case II
$= V\ 1.108 \times R\ 27{,}000/22{,}000 = 1.358$.

% V_4	% H.P.$_4$
151.8	—
124	176.8
107.3	125.5
87.6	81.5
75.8	66.3
67.7	60.4
61.8	65.8

Curves for the different values of W may now be added to Fig. 3 and when read against effective h.p. curve values may be obtained for the top speed, rate of climb, stalling speed and best climbing speed for each value of W.

The following table may then be compiled:—

Case.	W.	Top speed m.p.h.	Max. rate of climb ft. per min.	Stalling speed (V_s) m.p.h.	(V_c) Horizontal speed during max. climb m.p.h.
I	20,000	108.5	660	59	69.2
II	22,000	107	550	62	71.0
III	25,000	105	395	66	74·5
IV	27,000	103·5	297	68.5	77·5

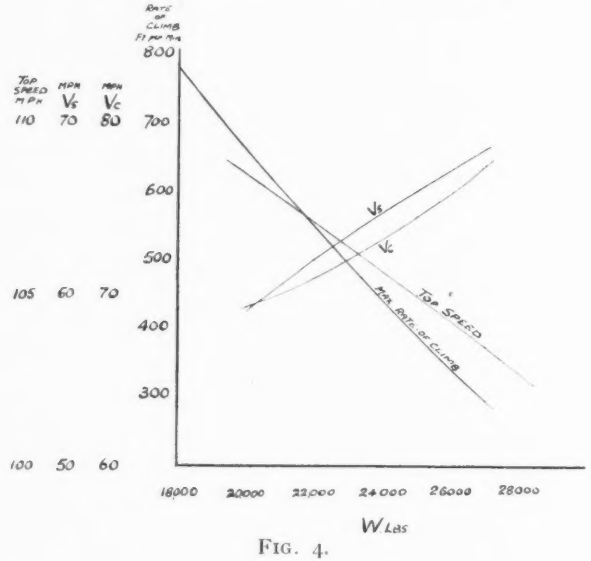


FIG. 4.

These figures are obtained as follows:—

CASE I.

The top speed for this case is shown by Fig. 3 to be approximately 98 per cent. of the design speed (110 m.p.h.), *i.e.*, 108.5 m.p.h.

Curve Fig. 3 shows that h.p. available for climb = 37 per cent. (of total effective h.p. available).

$\therefore$ Rate of climb = $.37 \times 1{,}080 \times 33{,}000/20{,}000 = 660$ ft. per min.

$V_s = \sqrt{(W/\rho S k_L \text{ max.})} = $ ft./sec.

k_L max. for the particular aerofoil under consideration = .56.

The stalling speeds may appear rather large, but as there may be considerable scale effect k_L max. of .6 may possibly be realised in actual practice.

$V_s = \sqrt{(20{,}000/.00238 \times 2{,}000 \times .56)} = 59$ m.p.h.

$V_c = 63.0$ per cent. $110 = 69.2$ m.p.h.

CASE II.

Top speed = 100 per cent. design speed = 107 m.p.h.

h.p. available for climb = 34 per cent.

$\therefore$ Rate of climb = 550 ft. per min.

$V_s = \sqrt{(22{,}000/2.66)} = 62$ m.p.h.

$V_c = 66.5$ per cent. $107 = 71.0$ m.p.h.

CASE III.

Top speed, approximately 98 per cent. design speed = 105 m.p.h.
h.p. available for climb = 27.7 per cent.
∴ Rate of climb = 395ft. per min.
$V_s = \sqrt{(25{,}000/2.66)} = 66$ m.p.h.
$V_c = 69.5$ per cent. $107 = 74.5$ m.p.h.

CASE IV.

Top speed, approximately 96.6 per cent. design speed = 103.5 m.p.h.
h.p. available for climb = 22.5 per cent.
∴ Rate of climb = 297ft. per min.
$V_s = \sqrt{(27{,}000/2.66)} = 68.5$ m.p.h.
$V_c = 72.5$ per cent. $107 = 77.5$ m.p.h.

The curve Fig. 4 may then be drawn in which rate of climb, V_c, V_s and top speed are plotted against W.

Run to Get Off

Using formula and method as given in R. & M. 996 (H. Glauert):—

L_1 (ft.) $= (V_1^2/2gB) \log_e AV_1^2/(AV_1^2 - BV^2)$.
$A = 1.5\ T_1/W - \mu$.
$B = 1.8\ T_1/W - \mu$.
μ = coefficient of friction of wheel chassis (= .05).
V = speed at commencement of climb = 1.1 V_s.
V_1 = top speed of horizontal flight.
T_1 = thrust corresponding to V_1.

Assuming for each value of W the thrust at top speed is the same it can be taken as:—

$T_1 = 3 \times 450 \times .8 \times 550/156 = 3{,}800$lbs. (total for three engines).

In calculating thrust to be used in above formula the average top speed for the four cases, *i.e.*, 156ft. per sec. will be used.

W.	A.	B.	V ft./sec.	$V_1^2/2gB$.	AV_1^2.	BV^2	$AV_1^2/(AV^2 - BV^2)$.	Log e $AV_1^2/(AV^2 - BV^2)$.	L_1 Yards.
20,000	.235	.292	95	1350	5960	2635	1.8	.5878	265
22,000	.209	.261	100	1467	5150	2610	2.025	.705	345
25,000	.178	.224	106.5	1650	4240	2540	2.50	.9160	503
27,000	.161	.203	110.5	1745	3720	2480	3.0	1.096	640

These values for run to get off are plotted against all-up weights in Fig. 5.

We now have most of the performance characteristics required so that the aircraft can be considered against the British Civil Airworthiness requirements as regards take-off and climb as called for in A.P. 1208.

The actual requirements for this type of aircraft are to clear 66ft. in 656yds. horizontal projection from rest and to climb 1,180 feet in three minutes from rest.

Let the time to take-off or unstick = 12 secs. This is a fair average figure for such an aircraft.

Then the remaining time for climb = 2.8 mins.

∴ The minimum rate of climb must be 1,180/2.8 = 420ft. per min.

Firstly, consider the performance of the original aircraft at its all-up weight of 20,000lbs. (Case I).

Run to unstick	=265yds.
V_c	=70 m.p.h. =102 ft./sec.
Max. rate of climb	=660ft. per min. =11 ft./sec.
Time to climb 66 ft.	=6 secs.
Horizontal distance travelled while climbing 66ft.	=6 × 102 =612ft. =204yds.
Total distance travelled while climbing 66ft.	=265 + 204 =469yds.

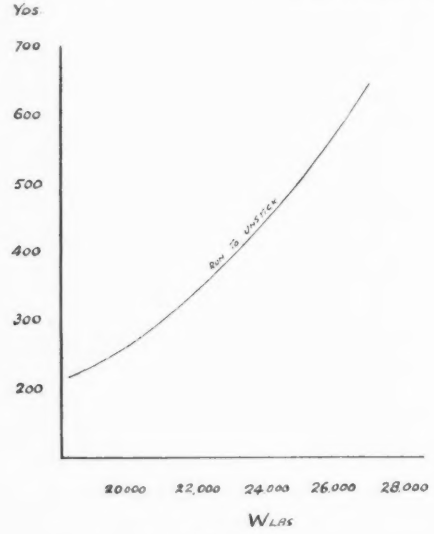


FIG. 5.

From the above it will be seen that the aircraft at this weight fully complies with the requirements.

Secondly, consider the performance of the aircraft if pay load be substituted for fuel at the time of taking-off as previously described; the take-off load =21,700lbs. and the maximum load after refuelling in the air =24,400lbs.

Run to unstick	=330yds.
V_c	=71 m.p.h. =104ft. per sec.
Max. rate of climb	=560ft. per min. =9.34ft. per sec.
Time to climb 66ft. =66/9.34 ...	=7.075 secs.
Horizontal distance travelled while climbing 66ft.	=7.075 × 104 =736ft. =245yds.
Total distance travelled while climbing 66ft.	=330 + 245 =575yds.

At this loading the aircraft still meets with the C. of A. requirements.

Loaded in the air to 24,400lbs. the aircraft will be able to fly at over 105 m.p.h. and climb at about 400ft./min.

An emergency landing with full tanks ought not to present any great difficulties provided the landing conditions are good, as the stalling speed would be in the region of 65 m.p.h. and the run to pull up =.1 VS^2 ft. per sec./3 =300 yards approximately.

The use of wheel brakes would, of course, reduce the length of landing run, and some method of jettisoning the fuel might be advisable for use in extreme circumstances.

It has been shown that the increase in pay load is 67.5 per cent.; this, however, is only in part due to refuelling in flight, greater advantage having been taken, in the one case than the other, of the allowable figures for C. of A. take-off and climb, quoted in A.P.1208.

To obtain a truer comparison then let it be assumed that the original aircraft takes the same advantage of these requirements, making the take-off load of the aircraft in each case = 21,700lbs.

Pay load of original aircraft then becomes $4{,}000 + 1{,}700 - (.37 \times 1{,}700)$ = 5,070lbs.

Pay load of the refuelled aircraft = 6,700lbs.

Increase in pay load = 6,700 − 5,070 = 1,630lbs. or 32.2 per cent.

The actual increase in pay load that would be made possible by refuelling in flight will obviously vary considerably with the different types of aircraft. It has, therefore, been attempted to show here, with an aircraft, the characteristics of which are perhaps a little below the present-day average, what increase in pay load might reasonably be expected, not necessarily the maximum that can be obtained; and from the foregoing it would appear that this figure might fairly be quoted as approximately 33 per cent.

Against the increased revenue that would result in commercial aviation from the employment of such a scheme, would have to be taken the cost of equipping and maintaining the refuelling service. It is, however, possible that aircraft which had become obsolete as passenger carriers might be utilised as tankers, although conclusions drawn from recent experiments indicate that refuelling in the air will best be accomplished by the use of tankers specially designed for their duty. Also that such aircraft must differ from orthodox design in numerous essential features; which would make possible the application of methods that would overcome the objections which are inherent in methods restricted to the use of standard aircraft.

It has not been attempted to discuss here the various methods or the manœuvring necessary for the making of contact between aircraft in flight, but the time occupied by the operation of refuelling should cause no appreciable delay in the progress of a flight since the receiving aircraft would be refuelled whilst travelling on its normal course at average speed.

The extent, however, to which any such methods could be employed in civil aviation would appear to depend almost entirely upon the degree of safety with which they could be applied; but, assuming that it can be established as a routine operation and carried out with safety, the refuelling of aircraft in flight should have a very extensive and economic application.

WING-BEATS—II.

J. D. BATTEN

In my article *Wing-Beats*, which appeared in this Journal, in the issue of October, 1930, I recorded a series of experiments demonstrating the strength and lightness of a spring formed by twisting skeins of natural silk.

My hope is that silk torses of this kind will fulfil, in human flight, the *postural* function of a bird's pectoral muscles, leaving to human effort the *phasic* function of these muscles, that is to say, the activity induced by rapid nerve impulses from the brain.

The ratio that may subsist between these two functions cannot, I think, be determined otherwise than by full-scale flight experiments, but the experiments already recorded give reasonable ground for the belief that the requisite human *phasic* output will be small in relation to the total weight movement.

The view which I wish to put forward is that an oscillation of the weight of the body between the air-supported wings is an essential movement in bird flight, and that a study of the factors controlling such oscillations cannot fail to be of significance to those attempting this manner of flight.

I apprehend that the function of such oscillation is to bring the wings intermittently into the position favourable for the propulsive stroke.

The charts given in my former article related only to the oscillations of a *single* arm; the positions, moreover, of the weight, power and fulcrum were transposed from the positions which they naturally hold in a flying bird.

I have now constructed a small model in which the weight is slung between a *pair* of wing spars.

The spars are supported at the assumed positions of air support under the wings, and the moment of the weight is counterbalanced by the torque of a pair of silk torses, set approximately in the position of a bird's pectoral muscles.

A similar arrangement is described in Chapter IV of my little book *An Approach to Wing Flight* (1928).

The advantages of the present model are:—

(1) That the thorax weight can be varied from one pound to three pounds at quarter-pound intervals.

(2) That the distance between the points of support can be varied from 30 inches to 50 inches at two-inch intervals (*i.e.*, one inch on each wing spar).

(3) That the tension of the silk torses can be readily adjusted to bring the system into horizontal equilibrium at each of the weight and distance intervals above stated.

The construction is shown, I hope, with sufficient clearness in the accompanying drawing and photograph:—

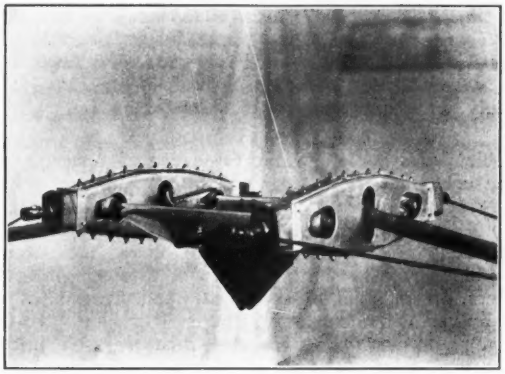


PHOTO I.

A pair of aluminium plates, marked as scales from 12 to 22 inches, are fixed on top of the wing spars and pierced with holes, to allow of the fixing on the underside of the wing spars of beechwood yokes which run on burnished brass rails screwed to the top of wooden uprights. The yokes, when black-leaded, run with very little friction.

A balanced fishing-rod arrangement, the line of which is a fine cotton thread tied to the butt ends of the two wing spars, enables me to give an upward pull while standing at sufficient distance to note the amplitude of the oscillations. The silk torses are enclosed in the shuttle-shaped duralumin sheaths shown in Photo I. These are copies in small of a larger construction shown in Photo II.

The occasion for this construction was as follows:—

> The silk torse enclosed in this frame is the lower of the two torses shown in the photographs reproduced in my previous article. It consists of six skeins of silk, each weighing $3\frac{1}{4}$ ounces. The lightness of such a spring in relation to the performance recorded is all that I could desire. On the other hand, the end pull on the bolts of the carriers is very great. By the impression of hardened steel balls on discs of mild steel, I have tested the end pull

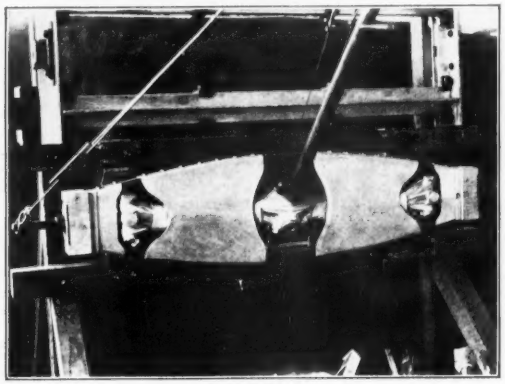
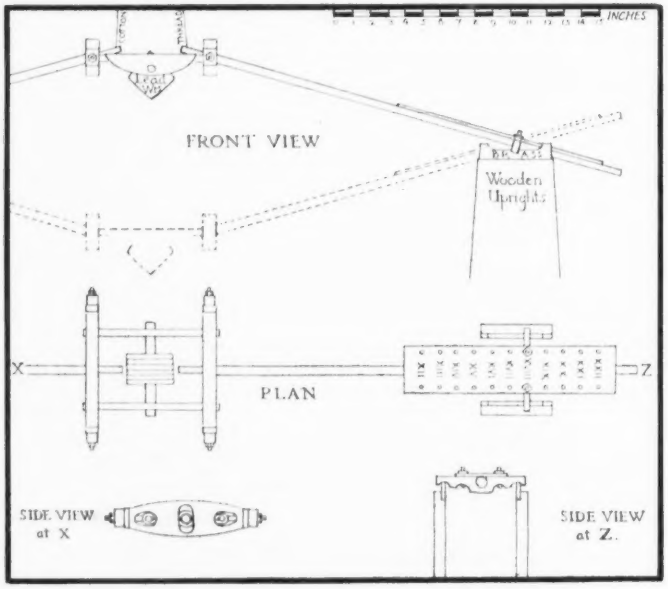


PHOTO II.

of the six-skein torse up to 2.62 tons. This reading was obtained by lifting the weighted arm to a determined angle, letting it fall to the limit of its swing, and catching it again on the upward rebound. I did not make any severer test because I was doubtful of the strength of the steel arm, which had already bent noticeably. I think I ought to allow for an end pull of three or four tons.

The problem was no longer the discovery of a spring of extreme lightness, but the construction of a frame of no excessive weight sufficient for such stress. My first attempt is shown in Photos VII-IX of my book *An Approach to Wing Flight*. It consisted of an opposed pair of arcs of spring steel (each 3/16in. thick, 1½in. wide, chord 30in.), the ends of which were held by blocks of duralumin and wood, through which passed the bolts of the carriers. The springs were restrained from bending beyond their original arc by vertical tie-rods and diagonal bracing. In the frame shown in the present photograph the same steel arcs are used, but the tie-rods and bracing are replaced by a sheath of 16 gauge duralumin. The whole construction weighs 16 pounds.



To return to the small model:—

The thorax weighs about 15 ounces; to this I add leaden washers, as make-weights, to bring the weight up to a true pound. Additional weights consist of squares of lead, pierced near one corner so as to hang on a light wooden rod (as shown in the drawing), each weighing ¼lb.

The thorax having been given a determined weight, and the yokes having been fixed under the wing spars at a determined distance, the wooden uprights which support the brass rails are shifted into the position which will give such run to the yokes as is required by the oscillations.

The torque of the silk torses can be adjusted by tightening or relaxing the end pull on the silk by means of the nuts and bolts of the carriers. These are tuned to bring the system to rest with the wing spars horizontal.

A slight repeated upward pull on the cotton thread is sufficient to induce and maintain a constant up and down oscillation of the thorax.

The amplitude of these oscillations can be observed by sighting the top of the thorax against marks placed on a window at the end of my workshop. These marks are made to tally with a wing spar angle of 22.5° above the horizontal. The angle below the horizontal is, as nearly as I can judge, the same. In my records I have described such oscillation as one of 45°.

My practice has been to observe with a stop-watch the time of 100 oscillations. At each position I have repeated this observation six times. The readings vary more than those recorded in my former article.

For example:—The six consecutive readings for the record of 75 seconds of Chart A were:

1	minute	17	seconds.
1	,,	17	,,
1	,,	$14\frac{3}{5}$	,,
1	,,	$15\frac{4}{5}$	,,
1	,,	$15\frac{2}{5}$	,,
1	,,	$14\frac{3}{5}$	,,

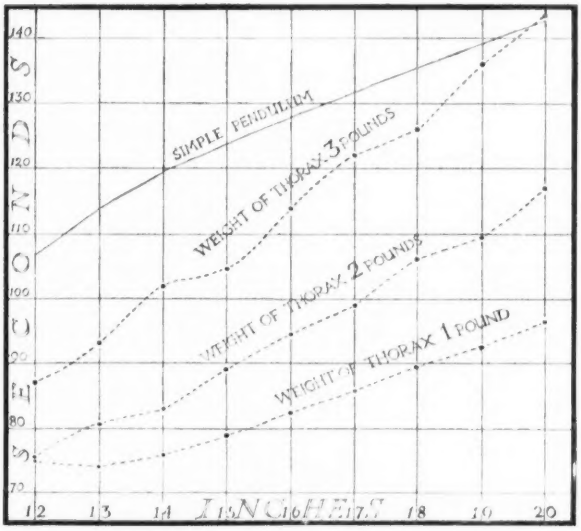


CHART A.

This is a characteristic sequence. The first readings are usually, but not always, the slowest.

In such a case an *average* reading did not seem appropriate. I therefore decided to record on the chart the fastest time out of six, taking fifth-seconds to the half-second above. I have adhered to this method without compromise, even when the results obtained appeared exceptional.

In Chart A three paths are plotted. In each of these the weight is constant, but the span length (measured from the torse to the yoke) is varied at intervals of one inch.

The counter curve which occurs between 12 and 14 of the one pound series is due, I think, to the weight of the aluminium plates fixed to the wing spars. When the thorax is more heavily weighted this deviation is not observable.

The deviations of the two pound and three pound paths are, I believe, accidental, and indicate only the faulty working of the model. The chief fault is a backward and forward rocking of the thorax, which increases with added weight, and which the attachments of the wing spars are not firm enough to control.

Readings for Chart A. (Times of 100 oscillations of 45°.) :—

(i) Thorax weight one pound.

At spar length	12	inches,	75	seconds.
,,	13	,,	74	,,
,,	14	,,	76	,,
,,	15	,,	79	,,
,,	16	,,	82½	,,
,,	17	,,	85½	,,
,,	18	,,	89½	,,
,,	19	,,	92½	,,
,,	20	,,	96½	,,

(ii) Thorax weight two pounds.

At spar length	12	inches,	75½	seconds.
,,	13	,,	80½	,,
,,	14	,,	83	,,
,,	15	,,	89	,,
,,	16	,,	94½	,,
,,	17	,,	99	,,
,,	18	,,	106	,,
,,	19	,,	109½	,,
,,	20	,,	117	,,

(iii) Thorax weight three pounds.

At spar length	12	inches,	87	seconds.
,,	13	,,	93	,,
,,	14	,,	102	,,
,,	15	,,	104½	,,
,,	16	,,	114	,,
,,	17	,,	122	,,
,,	18	,,	126	,,
,,	19	,,	136	,,
,,	20	,,	143½	,,

I did not carry the test to a greater spar length than 20 inches because, after that, the model began to run off the rails.

The " simple pendulum " curve given for the purpose of comparison is, as before, set out from the formula

$$t^2 = \left(\frac{\pi^2}{g}\right) l$$

In Chart B the spar length remains constant, but the thorax weight is increased by quarter-pound additions.

Readings for Chart B. (Times of 100 oscillations of 45°. The spar length is 17 inches throughout) :—

Thorax weight	1	pound,	84 seconds.
,,	$1\frac{1}{4}$	,,	$86\frac{1}{2}$,,
,,	$1\frac{1}{2}$	,,	93 ,,
,,	$1\frac{3}{4}$	,,	96 ,,
,,	2	,,	99 ,,
,,	$2\frac{1}{4}$	,,	$109\frac{1}{2}$,,
,,	$2\frac{1}{2}$	,,	113 ,,
,,	$2\frac{3}{4}$	,,	119 ,,
,,	3	,,	125 ,,

The crosses × on this chart mark the comparative readings on Chart A.

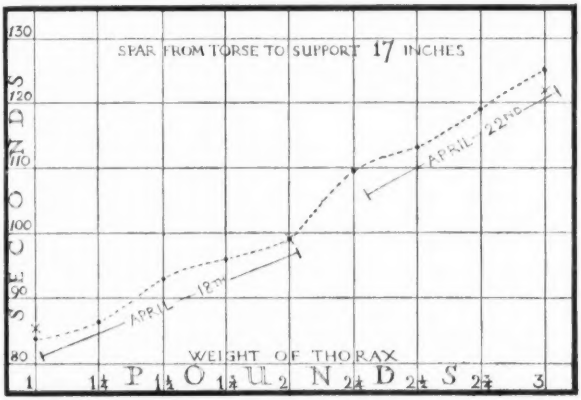


CHART B.

JOHN D. BATTEN.

September, 1931.

[Note.—At the close of my former article I expressed a hope that I might be able to establish a relation between the period of the oscillations therein recorded and the period of the wing-beats of birds. Towards this end I have made very little progress. The only bird whose wing-beats I have been able to observe with accuracy is the heron. These birds I can often watch in the evening as they fly back from a favourite fishing ground in Syon reach.

The longest and most reliable observations are three records of 50 beats each, taken on different evenings, but possibly of the same bird.

The stop-watch timings were $18\frac{2}{5}$ seconds, $18\frac{1}{5}$ seconds and 18 seconds, giving an average of 164-165 beats a minute.

One day in Kew Gardens I saw three swans flying overhead. They were in close arrow-head formation and kept perfect time with each other in their wing-beats. These were too fast for me to count, but from the sound of the pulse of their wings I estimated that they were nearly four beats a second.

Lilienthal gives the period of a stork's flight as two beats a second, and I believe that Dr. Hankin attributes the same period to the adjutant.

May I ask if any of your readers have records of the flight of the flamingo or of the pelican. According to Dr. Heimroth's tables, the pelican is, after the condor, the heaviest of flying birds.—J. D. B.]

SUMMARY OF THE SOCIETY'S ACTIVITIES

DECEMBER, 1930—DECEMBER, 1931

The following places on permanent record in the Journal the notices which have appeared in the Monthly Notices inset in the Journal, and so summarises the Activities of the Society for the year.

President

The Council at their meeting on May 19th, 1931, unanimously elected Mr. C. R. Fairey, M.B.E., F.R.Ae.S., as President for a second year (October, 1931—September, 1932).

During Mr. Fairey's first year of office a series of lectures were arranged which proved of such interest that the attendance was well above the average. Mr. Fairey has taken a keen and practical interest, as well, in the financial side of the Society. Thanks to his own personal efforts the Endowment Fund has been increased during his first year of office by over £1000. He has further put forward a number of suggestions for adding to the fund, many of which it is expected will, during his second year of office, bear fruit. In many ways the President has come to the assistance of the Society during his first year of office, and has on a number of occasions, as the Wilbur Wright Memorial Lecture and Conversazione, paid personally the considerable deficit which the Society would otherwise have had to meet. He has also entertained certain of the lecturers to the Society to enable them to meet the leaders in this country in their own particular sphere of aeronautics. Mr. Fairey's first year of office has coincided with one of the most severe financial depressions this country has experienced, but his generous help has enabled the Society to come through it with its finances unimpaired.

Vice-Presidents

At the Council Meeting held on May 19th, 1931, the following were re-elected Vice-Presidents of the Society for 1931-32:—

Professor L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.
Lieut.-Col. J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.P.
Mr. H. E. Wimperis, C.B.E., M.A., F.R.Ae.S.

At the same meeting Mr. Griffith Brewer, F.R.Ae.S., was elected a Vice-President in place of Air Vice-Marshal Sir Vyell Vyvyan, who resigned from the Council in March.

Council

The following is the full Council for 1931-32:—

President:
Mr. C. R. Fairey, M.B.E., F.R.Ae.S.

Past-President:
Colonel the Master of Sempill, A.F.C., F.R.Ae.S.

Vice-Presidents:

Lieut.-Col. J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.I.Ae.E., M.P.
Mr. H. E. Wimperis, C.B.E., F.R.Ae.S.
Prof. L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.
Mr. Griffith Brewer, F.R.Ae.S.

Council:

Captain P. D. Acland.
Major T. M. Barlow, M.Sc. (Eng.), M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. Robert Blackburn, O.B.E., Assoc.M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., M.I.Ae.E.
Mr. M. L. Bramson, A.C.G.I., F.R.Ae.S., M.I.Ae.E.
Major J. S. Buchanan, O.B.E., A.M.I.Mech.E., F.R.Ae.S.
Major G. P. Bulman, O.B.E., B.Sc., A.F.R.Ae.S.
Mr. A. H. Hall, C.B.E., M.Inst.C.E., M.I.Mech.E., A.F.R.Ae.S.
Captain F. T. Hill, F.R.Ae.S., M.I.Ae.E., B.Sc., Wh. Ex.
Captain A. G. Lamplugh, F.R.Ae.S., M.I.Ae.E.
Mr. M. Langley, A.M.I.Ae.E., A.M.Inst.N.A.
Mr. W. O. Manning, F.R.Ae.S.
Lieut.-Col. F. C. Shelmerdine, O.B.E., C.I.E., A.F.R.Ae.S.
Mr. A. F. Sidgreaves, O.B.E.
Mr. L. A. Wingfield, M.C., D.F.C., A.R.Ae.S.I.
Mr. R. McKinnon Wood, O.B.E., M.A., Assoc.M.Inst. C.E., F.R.Ae.S.

Hon. Treasurer:

Major D. H. Kennedy, O.B.E., F.R.Ae.S.

Hon. Solicitor:

Mr. L. A. Wingfield, M.C., D.F.C., A.R.Ae.S.I.

Hon. Librarian:

Mr. J. E. Hodgson.

Hon. Accountant:

Mr. A. N. D. Smith, F.I.C.A.

Secretary and Editor:

Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

Committees of Council

The following are the Committees of Council for the year 1931-32:—

Grading Committee:

Captain F. S. Barnwell, Mr. R. A. Bruce, Major F. A. Bumpus, Mr. W. S. Farren, Lieut.-Colonel L. F. R. Fell, Mr. A. Gouge, Captain F. T. Hill, Mr. R. J. Mitchell, Mr. W. P. Savage, Colonel the Master of Sempill, Prof. R. V. Southwell and Dr. H. C. Watts.

Finance Committee:

Captain P. D. Acland, Mr. E. C. Gordon England, Mr. C. R. Fairey, Captain F. T. Hill, Mr. J. E. Hodgson, Major D. H. Kennedy, Captain A. G. Lamplugh, Mr. W. P. Savage, Mr. F. R. Simms, Mr. A. N. D. Smith and Mr. L. A. Wingfield.

Informal Discussions' Committee:

Major T. M. Barlow, Mr. M. L. Bramson, Major G. P. Bulman, Mr. F. A. Foord, Mr. D. R. Pye and Mr. C. C. Walker.

Lectures Committee:

Mr. R. S. Capon, Captain F. Entwistle, Mr. H. Glauert, Major F. M. Green, Mr. S. Scott Hall, Captain G. T. R. Hill, Mr. H. B. Irving, Mr. M. Langley, Mr. R. K. Pierson, Mr. D. R. Pye and Mr. C. C. Walker.

Joint Standing Committee with the Society of British Aircraft Constructors and the Royal Aero Club:

Colonel the Master of Sempill, Air Vice-Marshal Sir Vyell Vyvyan and Captain A. G. Lamplugh.

Educations and Examinations Committee:

Major T. M. Barlow, Prof. L. Bairstow, Mr. R. S. Capon, Mr. W. E. Dumbrill, Mr. Eadon, Captain F. T. Hill, Prof. Melvill Jones, Mr. W. M. Page, Dr. N. A. V. Piercy, Mr. R. K. Pierson, Mr. D. R. Pye, Mr. W. P. Savage, Mr. H. T. Tizard, Captain G. W. Wilkinson and Mr. L. A. Wingfield.

Medals and Awards Committee:

Major T. M. Barlow, Mr. Griffith Brewer, Major J. S. Buchanan, Mr. A. H. R. Fedden, Group Capt. G. B. Hynes, Mr. W. O. Manning, Sir A. Verdon-Roe, Mr. G. R. Volkert, Mr. C. C. Walker, Mr. L. A. Wingfield and Mr. R. McKinnon Wood.

Representatives on Other Bodies.

British Engineering Standards Association Aircraft Committee: Major R. H. Mayo and Dr. H. C. Watts.

Advisory Council of the Science Museum: Colonel the Master of Sempill.

National Central Library: Mr. J. E. Hodgson.

Students' Section: Mr. T. Tanner (Honorary Secretary).

Association of Special Libraries and Information Bureau: Mr. J. E. Hodgson (Hon. Librarian).

Advisory Committee on Aeronautical Education of the Imperial College: Mr. C. R. Fairey.

B.E.S.A. Committee on Symbols and Abbreviations Used in Engineering: Major A. R. Low.

Lloyds Aviation Committee: Lieut.-Col. J. T. C. Moore-Brabazon.

British Corporation Register of Shipping and Aircraft, Aviation Committee: Colonel the Master of Sempill.

Seagrave Memorial Fund Committees: Mr. C. R. Fairey.

British Gliding Association: Council: Colonel the Master of Sempill. Technical Committee: Capt. J. L. Pritchard.

Elections

The following were elected members of the Society in the grades indicated on December 16th, 1930:—

Associate Fellows.—Rupert Beaney, John Dunbar Blyth, Ernest Edward Chatterton, Frank Duncanson, Donald Lister, Thomas Tanner (from Student), Montague Sidney William Templeman (from Student).

Associate Member.—Charles Snow.

Associates.—Robert Limbert Carter, John Athelstan Victor Nisbet, Roger Lovett Nowland, Reginald Reynolds, Walter Ernest Vick.

Students.—George Bernard Dwyer, Eric Malcolm Gibbs, Stanley George Hooker, William John Claude Humphrey, Arthur Edwin Smith, Clifford H. Jackson, Richard Henry Mead, William Halse Paine, Gordon Thripp.

Companion.—John Harold Edge.

On January 20th, 1931 :—

Fellows.—Glenn L. Martin, Holden Chester Richardson.

Member.—Francis McKenna.

Associate Fellow.—Frank Gordon Evans (from Student).

Associate Member.—Mostafa Riad Moursi.

Associate.—Ovid Ottley.

Students.—Joseph Ronald Barnard, Sydney James Cater, Colin James Craig Ewing, Christopher John Reming, Louis Levy, Geoffrey Peter Kirk, William Henry Lewis, Wallace Eric Locke, Geoffrey Alexander McMillan, James Ernest Raddings, Albert Cyril Shaw, Rex Watson.

On February 17th, 1931 :—

Member.—Alan Theodore Eden Eadon (from Assoc. Member).

Associate Fellows.—Senr. Juan de la Cierva, William Crane Cunnington, Alfred Lancelot Dimmock, Pierre Victor Lamarque, William Alban Tamblin.

Associates.—George Walter Arthur Allen, Thomas Henry Blake, Frederick John Dean, James Bernard Terence Whitehead.

Students.—Sydney Allard, Bernard Horace Becker, Frederick Clifford Bertram, Terence Michael Anthony Donlea, Hugh Evans, Ronald John Fyfe, Neville Durrant New, John Henry Payne, William Edward Willoughby Petter, Frank Squire, William Thomas Wakeham, Edwin James Weeks.

On March 17th, 1931 :—

Fellow (from Associate Fellow).—Arthur Gouge.

Associate Fellows.—Arthur James Lorne (from Associate Member), John Alfred Medhurst, Frank Nixon.

Associate (from Student).—Frank Lionel Tollow.

Students.—George Norman Beckmann, Bosco Davitcho, Herbert Marcus Kemp, Roy Dennis Stoner.

On April 21st, 1931 :—

Associate Fellows.—Kshetra Mohan Raha, Seymour Cunningham Redshaw (from Associate), Paul Hamar Stanley, Clarence Marshall Young.

Associate Member.—Walter Croft Clayton.

Associates.—Arthur Haycroft Acford, William Henry Burn, John Talbot Dyment (from Student).

Students.—Robert Henry William Beer, Eric Joscelyn George, Robert Fuller George, Cyril Herbert Nundy, David Hay Surgeoner.

Companions.—Sydney Hansel (from Student), E. Colston Shepherd.

On May 19th, 1931 :—

Associate Fellows.—Adirio Orfelio Jesson, Joseph Kampe de Feriet.

Associate Member.—Robert Ross.

Associates.—Stanley Alfred Seager, Harold Stringer.

Students.—Eugene James Earle, Ernest Parr Hessey, Robert Fairfax Lucy, Henry Charles Stocks, Theodore Michael Walker.

On June 22nd, 1931 :—

Associate Fellows.—William George Bird, Carl Berges Fritsche, John Megarry Furnival, Beverley Strahan Shenstone (from Student).

Associate Member.—Manohar Gopal Pradhan.

Students.—James Van Stockum Brotherhood, Neville Gainford Dixon, Jack Eliot Duckham, Arthur James Horace Hart, Tulsi Dass Kumar, Harry Ledger, John Nicholls, Cyril Arundel Penberthy, Peter Reginald Poole, William Lawrence Thomas.

Companion.—William Pasifull Lascelles Bowen (from Student).

On July 24th, 1931 :—

Associate Fellow.—Eric William Edwards.

Associate Member.—William George Bruce Callingham.

On September 8th, 1931 :—

Fellow.—Ralph Hazlett Upson.

Associate Fellows.—Inglis Joseph Gerard, Doris Mona Hirst (from Companion), Henry Nigel St. Valery Norman (from Companion), Neill Charles Ogilvie-Forbes.

Associate Members.—Frederick Steadman Farrow, Arthur Steele Suddes.

Associates.—William Alexander Campbell, George Brereton Sadleir Falkiner (Australian Branch), Roderick George Morrison, Alan Charles Moyle (Australian Branch), Thomas James William Samuel Pearce, Willows Septimus Shaw, Ethelbert Victor Wraight (from Student).

Students.—Alfred Brain, Leslie Victor Clark, Thomas Alexander Couper (Australian Branch), Geoffrey Uffindell Hayns, Jack Kenneth Woolgar Wheatley.

Companions.—Harold M. Probyn (Squadron Leader, R.A.F.), Laurence Chase Sharman (Commander, R.N.), Charles Amherst Villiers.

On October 13th, 1931 :—

Associate Fellows.—Richard Milroy Clarkson, Hayne Constant, John Joseph Green (from Student), Joseph Martin Heesem (re-elected), Ernest Platton King, John Henry Broughton Larrard, Jean Pontremoli, William Norman Roberts.

Associate.—Joseph Williams.

Students.—Lorne Stuart Campbell, Noel Hogman, John Wesley Loader, Leslie Woodhouse Reeve, Alexander Phillips West.

Companions.—Robert Milroy Hayes (from Student), Thurstan T. James, Harriet Mary St. George Knightley.

On November 10th, 1931 :—

Associate Fellows.—Napier John Gill, John Mathew Hampden Hoare (from Associate), Michael Francis Magill (re-elected), Man Mohan Singh, Albert Gordon Store (from Student).

Associate Members.—Anath Bandhu Ray, Edward James Cadell Rennie (Australasian Branch).

Associates.—Alfred Pelton Poschinger (Australasian Branch), Madan Lal Sodhi (from Student).

Students.—Richard Cox Abel, James Macquarie Antell (Australasian Branch), Erich Carl Albert Backhaus, John R. Cotton, Siegfried Charles Fairbairn, Joseph Fogg (Australasian Branch), John Martin Freeman, Herbert Frederick Goldsmith (Australasian Branch), Albert Pascal Hall, Frank Robert Coupland Hounsfield, Ahmed Mohamed Mostafa, Alan Frederick Walsh.

Companion.—Miss A. D. Betts.

Annual General Meeting

The Annual General Meeting of the Society was held on March 30th, 1931, in the Library of the Society.

Present:—

Mr. C. R. Fairey, M.B.E., F.R.Ae.S., President, in the chair.

Council: Messrs. Barlow, Blackburn, Buchanan, Bulman, Kennedy, Lamplugh, Manning, Master of Sempill, Wimperis and Wingfield.

Ordinary Members: Miss L. Chitty, Messrs. R. E. H. Allen, G. N. Ashcroft, R. L. Carter, C. N. Colson, J. F. Cuss, H. Glaser, C. W. Lawson, G. Merton, F. A. Norton and B. M. Whitehead.

Captain J. Laurence Pritchard (Secretary), Miss Jarvis and Miss Todd.

The notice convening the meeting was read and the Minutes of the last General Meeting, having been published in the JOURNAL for December, 1930, were taken as read, and signed.

The President, in opening the meeting, reviewed the year's activities as detailed in the Annual Report of the Council. It had been a year of great progress in the matter of membership, lectures and papers read and published, in increased circulation of the JOURNAL, and added prestige not only at home but in every part of the world. Dealing with the Annual Balance Sheet, the President emphasised that, while an actual increase of income over expenditure was shown, this had only been made possible by grants which had generously been forthcoming, and that it was the aim of the Council, through the Endowment Fund, to make the Society self-supporting. He asked all members to keep the Endowment Fund constantly before them and to help in every possible way, either by contributing or by any suggestions or names of those who might be approached.

The President paid tribute to the Daniel Guggenheim Fund for the Promotion of Aeronautics, the Air Ministry, the Society of British Aircraft Constructors and the Society of Motor Manufacturers and Traders, for their generous help in enabling the Society to achieve all that it had achieved during the past few years.

The President concluded his speech by thanking the Council and officers and the various Committees for the very hard work they had put in during the year.

As announced in the April JOURNAL, no election to Council was necessary this year, there being the same number of candidates as there were vacancies. A full list of the Council for 1931-2 appeared in the April issue.

Mr. Wingfield proposed, and Mr. Manning seconded, that Messrs. Price, Waterhouse and Co. be re-appointed Auditors. The resolution was carried unanimously.

The following alteration to Rule 86 was considered:—

> " One half of the Council (excluding the President and the Immediate Past-President if a member of Council) shall retire annually. The members who shall retire shall be those longest in office, except as

provided in Rule 92. Retiring members of Council who have served for two terms in succession (four years) shall not be eligible for re-election until the next annual election, when they will be eligible."

Major Kennedy moved that the resolution be deferred for at least five years as he considered it would not be in the best interests of the Society to take any step which would limit its power to draw upon the help and advice which could be given by members of the aeronautical community on the Society's Council. Major Kennedy pointed out that the number of useful people available was bound to be small for, at any rate, the next few years.

Dr. Merton suggested that the matter might be dealt with by the appointment of special people as Vice-Presidents, but it was pointed out that under the present rules this would not be practicable as all the Society's Vice-Presidents must be members of Council.

Mr. Wingfield pointed out that the main reason for submitting the resolution was to facilitate the carrying out of a decision previously arrived at by the Council—that awards should not be made to members of Council.

The amendment was then put to the meeting and defeated. The original resolution was then seconded by Flight Lieutenant Allen and carried.

Colonel the Master of Sempill (Immediate Past-President) proposed a cordial vote of thanks to Mr. Fairey for the tremendous amount of enthusiasm he was putting in as President of the Society, which he hoped he would be able to continue for many years.

Mr. Fairey, in responding, again laid stress on the importance of the Endowment Fund, which must not be confused with the scheme for a new building. What he wanted to see in the near future was a sound financial basis on which the Society could carry on and increase its normal activities and render itself independent of grants which had been so generously given hitherto, and without which the Society's present position could never have been achieved.

The meeting then closed.

Lectures

The following Lectures were read before the Society in 1931 :—

January 8th.—Mr. A. Gouge, F.R.Ae.S., " Some Aspects in the Design of Sea-going Aircraft."

January 22nd.—Squadron Leader W. R. D. Acland, D.F.C., A.F.C., " Deck Flying."

January 29th.—Herr A. Lippisch, " The Development and Construction of Sailplanes and Gliders."

February 26th.—Captain F. Entwistle, B.Sc., " Meteorological Aspects of Gliding and Soaring."

March 12th.—Capt. Carl Florman, " Night Air Mails."

March 19th.—Dr. W. Hoff, " Research Work in the D.V.L."

April 16th.—Dr. A. H. Davis, " Noise."

April 30th.—Dr. Manfred Curry, " Aerodynamics of Sails."

May 14th.—Mr. Carl B. Fritsche, A.F.R.Ae.S., " The Metal-Clad Airship."

September 16th.—Mr. Glenn L. Martin, F.R.Ae.S., the Nineteenth Wilbur Wright Memorial Lecture, " The Development of Aircraft Manufacture."

October 15th.—Mr. H. Sutton, M.Sc., A.F.R.Ae.S., " The Protection of Aircraft Materials."

October 29th.—Captain A. G. Lamplugh, F.R.Ae.S., M.I.Ae.E., " Accidents in Civil Aviation."

November 5th.—Mr. H. B. Irving, B.Sc., A.F.R.Ae.S., and Mr. A. V. Stephens, B.A., " Safety in Spinning."

November 9th.—Captain W. J. McDonough, "The Aeroplane as an Aid to Mineral Exploration" and "The Operation of Aircraft in Sub-Zero Temperatures."

November 19th.—Mr. H. Constant, A.F.R.Ae.S., "Aircraft Vibration."

December 3rd.—Mr. S. Scott-Hall, M.Sc., D.I.C., A.F.R.Ae.S., "Wheel Brakes and Undercarriages."

December 10th.—Mr. W. S. Farren, M.B.E., M.A., F.R.Ae.S., M.I.Ae.E., "Air Flow."

December 17th.—Dr. G. V. Lachmann, A.F.R.Ae.S., "Control Beyond the Stall."

The following is a list of the principal lectures before the Branches:—

January 2nd.—Hull and Leeds Branch, "Evaporative Cooling of Aero Engines," by Mr. J. E. Ellor.

January 8th.—Yeovil Branch, "Aircraft Production Methods in America," by Mr. R. A. Bruce, F.R.Ae.S.

January 8th.—Gloucester and Cheltenham Branch, "Boat and Float Seaplanes," by Mr. V. S. Gaunt, A.M.I.Ae.E.

January 15th.—Gloucester and Cheltenham Branch, "Rigging and Assembly of Aeroplanes," by Mr. Vick.

January 16th.—Manchester Branch, "The Practical Lubrication of Aircraft Engines," by Messrs. Shell Mex, Ltd.

January 22nd.—Yeovil Branch, "Model Aeroplanes," by Mr. W. Rigby.

January 26th.—Oxford Branch, "Gliding and Soaring," by Colonel the Master of Sempill, A.F.C., F.R.Ae.S.

January 22nd.—Gloucester and Cheltenham Branch, "Controls, Faults and Diagnosis," by Mr. W. G. Gibson, A.R.Ae.S.I.

January 29th.—Yeovil Branch, "Machining and Working of Stainless Steel," by Mr. R. Waddell.

January 29th.—Gloucester and Cheltenham Branch, "Defects and Deterioration," by Mr. Gibson.

January 30th.—Hull and Leeds Branch, "Gliding and Soaring," by Colonel the Master of Sempill, A.F.C., F.R.Ae.S.

February 3rd.—Manchester Branch, "The Evaporative Cooling of Aero Engines," by Mr J. E. Ellor.

February 5th.—Bristol Branch, "American and Canadian Aviation," by Capt. J. Laurence Pritchard, Hon.F.R.Ae.S.

February 5th.—Gloucester and Cheltenham Branch, "The High Tension Magneto," by Mr. N. Schobel.

February 5th.—Yeovil Branch, "Westland Wapiti in Australia," by Squadron Leader C. T. Anderson, D.F.C.

February 12th.—Gloucester and Cheltenham Branch, "Heat-Treatment of Steel," by Mr. A. L. Williams, B.Sc., A.M.I.Mech.E.

February 12th.—Yeovil Branch, "Spinning," by Mr. S. Scott-Hall, M.Sc., D.I.C., A.F.R.Ae.S.

February 19th.—Yeovil Branch, "Lay-out and Equipment of Service Aircraft," by Squadron Leader R. B. Sorley, D.S.C., D.F.C.

February 24th.—Manchester Branch, "Machine Tools," by Messrs. Alfred Herbert, Ltd.

February 26th.—Gloucester and Cheltenham Branch, "Motor Fuels and Modern Methods of Testing," by Mr. H. C. Tett, B.Sc., D.I.C., of the Anglo-American Oil Co., Ltd.

February 26th.—Yeovil Branch, "Latest Aircraft Instrument Developments," by Major C. J. Stewart, O.B.E., F.R.Ae.S.

February 27th.—Hull and Leeds Branch, "Aircraft Light Alloys," by Mr. H. Sutton, M.Sc., A.F.R.Ae.S.

March 5th.—Gloucester and Cheltenham Branch, "Inspection of Timber," by Mr. G. G. Smith.

March 12th.—Yeovil Branch, "Metals," by Mr. W. K. Norton, A.I.D.

March 12th.—Gloucester and Cheltenham Branch, "Testing of Aero Engines and their Components," by Mr. E. W. Densham, A.M.I.Ae.E.

March 19th.—Gloucester and Cheltenham Branch, "Care and Maintenance of Water-Cooled Engines," by Mr. Kier Smith, of Messrs. Napier and Son, Ltd.

March 26th.—Gloucester and Cheltenham Branch, "Mechanical Testing of Aircraft Materials," by Mr. L. Nethercott, A.R.Ae.S.I.

March 27th.—Hull and Leeds Branch, "The Flying of High-Speed Seaplanes," by Squadron Leader A. H. Orlebar, A.F.C.

April 9th.—Gloucester and Cheltenham Branch, "Manufacture of Steel Tubes," by Mr. W. W. Hackett, J.P., M.I.Ae.E., of Messrs. Accles and Pollock, Ltd.

April 13th.—Coventry Branch, "Helicopters," by Captain R. N. Liptrot, A.F.R.Ae.S., M.I.Ae.E.

April 16th.—Gloucester and Cheltenham Branch, "Stainless Steels," by Mr. J. Hopcroft, of Messrs. Thos. Firth and Sons, Ltd.

April 27th.—Coventry Branch, "Streamlines in Air and Water," by Mr. W. S. Farren, M.B.E., F.R.Ae.S., M.I.Ae.E.

May 4th.—Oxford Branch, "Early Flying Experiences," by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.I.Ae.E., M.P.

October 1st.—Gloucester and Cheltenham Branch, "Recent Developments in Aircraft Engineering," by Major T. M. Barlow, M.Sc., F.R.Ae.S.

October 8th.—Gloucester and Cheltenham Branch, Lecture by Dr. L. Aitchison.

October 20th.—Bristol Branch, "Soaring Flight: Its Function in Aviation," by Mr. E. C. Gordon England, A.F.R.Ae.S.

October 22nd.—Gloucester and Cheltenham Branch, "Nickel and its Alloys," by a representative of the Mond Nickel Co.

October 29th.—Yeovil Branch, "The Petter Atomic Diesel Engine," by Mr. H. Sammons, Chief Engineer, Messrs. Petters, Ltd.

November 5th.—Yeovil Branch, "Plating Processes," by Mr. W. Merry, of W. Canning and Co., Ltd.

November 12th.—Yeovil Branch, "Jupiter Aero Engines," by Mr. E. W. Densham, A.M.I.Ae.E.

November 17th.—Bristol Branch, "High-Speed Aircraft," by Major J. S. Buchanan, O.B.E., F.R.Ae.S.

November 19th.—Yeovil Branch, "Model Aircraft," by Mr. W. McDermott.

November 19th.—Gloucester and Cheltenham Branch, Lecture by Squadron Leader A. H. Orlebar, A.F.C.

November 20th.—Hull and Leeds Branch, "Speed in Aviation and What it Means," by Lieut.-Colonel W. Lockwood Marsh, O.B.E., M.A., LL.B., F.R.Ae.S.

November 26th.—Yeovil Branch, "The Use of Magnesium Alloy and Elektron on Aircraft," by Mr. E. Voss.

December 3rd.—Gloucester and Cheltenham Branch, "The Autogiro," by a representative of the Cierva Autogiro Co.

December 4th.—Yeovil Branch, "Air Photography; its Developments and Applications," by Flight Lieut. A. J. Elliott, R.A.F.

December 4th.—Bristol Branch, "Aeronautical Research Development," by Mr. E. F. Relf, F.R.Ae.S.

December 10th.—Yeovil Branch, "The Gliding Movement in England and Germany," by Mr. J. R. Ashwell-Cooke, Chairman of the London Gliding Club.

December 11th.—Hull and Leeds Branch, "Tests of Aircraft Structures and Components," by Mr. I. J. Gerard, M.Sc., A.F.R.Ae.S.

December 17th.—Yeovil Branch, "Twelve Years' Progress in Commercial Aviation," by Capt. G. P. Olley.

Students' Section

The following lectures were read before the Students' Section during the year:—

February 10th.—"Compressibility Effects in High-Speed Air Flow," by Mr. S. G. Hooker. (Awarded the Pilcher Memorial Prize.)

February 11th (Joint Meeting with City and Guilds Engineering Society).—"Streamlining," by Professor L. Bairstow, F.R.S., F.R.Ae.S.

March 3rd.—"The Contribution of the Glider to Aerodynamics," by Mr. W. S. Coleman.

March 10th.—"Seaplane Floats," by Mr. R. C. Passmore.

April 28th.—"Some Notes on Modern Problems in Rigid Airship Design," by Mr. E. Wieser, B.Sc., D.I.C.

November 17th.—Inaugural Address by Professor L. Bairstow, F.R.S., F.R.Ae.S., on "Applications of Aeronautical Research."

School Lectures

During the year the Public Schools were approached with the suggestion that members of the Society should deliver lectures before them. The response to the Council's suggestion was sufficiently great to warrant a special series of slides being prepared, with full notes on them, so that prospective lecturers would have the minimum amount of work to do in preparing the lecture.

A number of members of the Society at once signified their willingness to deliver a lecture before one of the Public Schools, and the Council will be glad to hear from any member who would lecture to a school in his neighbourhood or to his old school. The Council feel it is of great importance that the opportunity of rousing interest in the air among those who are bound to have a great influence during the next few years should be seized upon.

The following lectures have been arranged for and others are under consideration:—

October 10th.—Ipswich School. Mr. W. O. Manning, F.R.Ae.S.

October 23rd.—Merchant Taylors' School. Mr. C. R. Fairey, M.B.E., F.R.Ae.S.

October 30th.—Eton College. Colonel the Master of Sempill, A.F.C., F.R.Ae.S.

November 4th.—Radley College. Major D. H. Kennedy, O.B.E., F.R.Ae.S.

November 12th.—City of London School. Major D. H. Kennedy.

November 13th.—University College School. Mr. W. O. Manning, F.R.Ae.S

November 14th.—Mill Hill School. Captain A. G. Lamplugh, F.R.Ae.S., M.I.Ae.E.

November 17th.—Wrekin College. Major T. M. Barlow, M.Sc., F.R.Ae.S.

November 18th.—King Edward's School, Birmingham. Mr. R. Reynolds.

November 21st.—Clifton College. Professor A. J. Sutton Pippard, M.B.E., D.Sc., M.Inst.C.E., F.R.Ae.S.

November 23rd.—Birkenhead School. Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

November 24th.—Blackpool High School. Captain J. Laurence Pritchard.

November 24th.—Haberdasher Aske's Hampstead School. J. H. Edge, Esq., Comp.R.Ae.S.I.

November 25th.—Westminster School. Mr. C. R. Fairey.
November 25th.—Bristol Grammar School. Professor A. J. Sutton Pippard.
November 26th.—Bedford School. Major G. P. Bulman, O.B.E., A.F.R.Ae.S.
November 27th.—Haberdasher Aske's School, New Cross. Mr. M. L. Bramson, F.R.Ae.S., M.I.Ae.E.
December 1st.—Tonbridge School. Mr. J. E. Hodgson.
December 4th.—Hurstpierpoint College. Captain J. Laurence Pritchard.
December 8th.—Beaumont College, Windsor. Major T. M. Barlow.
December 10th.—Imperial Service College, Windsor. Major T. M. Barlow.
December 15th.—Borough Polytechnic Engineering Society. Mr. D. Hay Surgeoner.

Wilbur Wright Memorial Lecture

With the concurrence of Mr. Orville Wright and Mr. Griffith Brewer (Trustees of the Wilbur Wright Memorial Lecture Fund), the Council postponed the reading of the Wilbur Wright Memorial Lecture to Wednesday, September 16th, 1931. The date chosen was in the week following the Schneider Trophy Race, so that as many as possible of the distinguished visitors to this country should have an opportunity of meeting members of the Royal Aeronautical Society.

The lecture was given by Mr. Glenn Martin, the well-known American pioneer and aircraft constructor, on "The Development of Aircraft Manufacturing."

The lecture was preceded by a Council dinner and afterwards there was a reception and Conversazione.

The lecture was published in the Journal for October together with a list of those present at the Council dinner and Conversazione.

Endowment Fund Appeal

At Christmas, 1930, an appeal was circulated to all members for the Endowment Fund of the Royal Aeronautical Society. The whole of the heavy expenses of this appeal has been borne by the President, Mr. C. R. Fairey. Without the generous help Mr. Fairey immediately offered when the question of the appeal came before the Council for consideration, it would not have been possible to make it in the form it has been made, despite the urgency of raising the Endowment Fund. The Council wish to impress upon all the members of the Society that, to quote from the appeal, "the real value of the Society's work must always depend on the energy, the loyalty and the mutual co-operation of its officers and members."

Every member can help, not only by contributing within his or her means to place the Society on a satisfactory financial footing, but by drawing the attention of all, who may not be members of the Society but who are interested in the cause of aviation, to the appeal and to the work which the Society is doing.

A society which has numbered among its members such well-known pioneers as James Glaisher, F. M. Wenham, John Stringfellow, Horatio Phillips, Percy S. Pilcher and Otto Lillienthal, must progress.

In the list of Honorary Fellows appears the name of Patrick T. Alexander, who has given so much to aviation. In the list appear also two names, Dr. F. W. Lanchester and Professor L. Prandtl, to whom aviation of to-day owes its very foundation stone, in the Lanchester-Prandtl theory. To quote from the President's address on the delivery of the Wilbur Wright Memorial Lecture, May, 27th, 1926, "No prophet is honoured in his own country, and we may well be ashamed that British scientists did not follow up Dr. Lanchester's work with vigour and appreciation. Joukowski and Prandtl, however, made full use

of his work. Prandtl began in 1910 and by the end of the war had stabilised Lanchester's vortex theory by practical experiment." It was on this day that Dr. Lanchester was awarded the Gold Medal of the Society, the highest honour in the world which is awarded for accomplishment in aeronautical science.

To-day the leaders in every branch of aviation are members of the Society, and it is safe to say that whatever progress is being made, scientific, industrial or otherwise, is due in a very large measure to those who are members of the oldest aeronautical society.

Greater progress, however, would be made, if the Council had at their disposal a secure income which would enable them to legislate ahead for the obtaining and printing of information, and for carrying out other schemes for which there has been a crying need for some years. It is for these purposes, as well as for those outlined in the appeal, that every possible help which can be given should be given *now*

On the 25th of November, 1931, the Endowment Fund reached a total of £1,922 8s. 1d.

The following are additional subscriptions to those which have already been acknowledged in the Journal for March, p. 248:—

	£	s.	d.
Already acknowledged	344	4	6
Oliver Thorneycroft, Esq., O.B.E., A.F.R.Ae.S.	1	0	0
Rubery, Owen and Co.	10	10	0
Woods, Sons and Co.	5	5	0
James C. Nicklin, Ltd.	5	0	0
London Label Co. Ltd.	2	2	0
The International Zeppelin Transport Corporation	25	0	0
E. V. Dolby, Esq., Comp., R.Ae.S.I.	1	1	0
Farmer Stedall and Co.	10	10	0
F./O. L. T. Pankhurst, A.M.I.Ae.E.	0	10	0
Osborne, Stevens and Co., Ltd.	5	5	0
Wing Cmdr. H. Blackburn, M.C., A.F.C., A.F.R.Ae.S. ...	0	10	6
R. F. Dagnall, Esq.	3	3	0
Capt. H. F. Jackson (Founder Member)	1	1	0
C. E. T. Maguire, Esq., Comp., R.Ae.S.I.	0	10	6
M. W. Wood, Esq., A.F.R.Ae.S.	0	10	6
Norman B. Scott, Esq., Stud., R.Ae.S.I.	0	10	0
Messrs. C. Lindley and Co., Ltd.	5	5	0
R. A. Chalmers, Esq.	10	10	0
F. R. B. King, Esq., Stud., R.Ae.S.I.	1	1	0
The British Gliding Association	10	0	0
Flt.-Lt. R. A. Seaton, A.F.R.Ae.S.	1	1	0
Dunlop Rubber Company	105	0	0
Callender's Cable and Construction Co., Ltd.	10	10	0
The Surrey Gliding Club	1	1	0
A. G. Hazell, Esq.	3	3	0
The Technological Institute of Great Britain	5	5	0
Messrs. Gale and Polden, Ltd.	25	0	0
H. B. Irving, Esq., A.F.R.Ae.S.	1	1	0
W. Broadbent, Esq.	5	0	0
British Gliding Association	1	19	0
J. G. Woollard, Esq., A.R.Ae.S.I.	1	1	0
Guild of Air Pilots and Navigators	5	0	0
C. E. Oake, Esq., A.R.Ae.S.I.	0	10	0
Flt.-Lt. T. N. McEvoy	3	3	0
	£612	3	0

Awards

The following awards were made for the year 1931:—

Simms Gold Medal.—To Dr. A. H. Davis for his paper on "Noise."

Taylor Gold Medal.—To Squadron Leader W. R. D. Acland, D.F.C., A.F.C., for his paper on "Deck Flying."

Silver Medal.—To Mr. H. C. H. Townend, B.Sc.(Eng.), A.F.R.Ae.S., for his work on the Townend Ring.

R.38 Memorial Prize.—Between Professor R. V. Southwell, M.A., F.R.S., F.R.Ae.S., and Miss L. Chitty, A.F.R.Ae.S., for their paper on "Some Problems of Primary Stress Determination in Airship Hulls"; and Mr. W. G. Bird, M.A., A.F.R.Ae.S., for his paper on "The Influence of Atmospheric Humidity and other Factors upon the Static Lift of Airships."

Busk Memorial Prize.—To Mr. A. Gouge, F.R.Ae.S., for his paper on "Some Problems in the Design of Sea-going Aircraft."

Pilcher Memorial Prize.—To Mr. S. G. Hooker for his paper on "The Compressibility Effects in High-Speed Airflow."

Elliott Memorial Prize.—For the half-year ended June, 1931, to Aircraft Apprentice S. G. Taylor, who obtained highest marks in the General Studies Paper in the "Passing Out" Examination.

Promotions and Honours

The following promotions of members were announced on January 1st:—

Air Vice-Marshal to be Air Marshal: Sir Robert Brooke-Popham, K.C.B., C.M.G., D.S.O., A.F.C.

Air Commodore to be Air Vice-Marshal: Felton Vesey Holt, C.M.G., D.S.O.

Flying Officers to be Flight Lieutenants:
William George Kentfield, A.M.I.Ae.E.
Archibald Henry Harrison, D.S.M., A.M.I.Ae.E.

The following has received the Order of the British Empire:—

R. S. Capon, B.A., F.R.Ae.S., Superintendent of Scientific Research, Royal Aircraft Establishment.

The following members of the Society were returned to Parliament in the General Election:—

Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., Vice-President
Mr. A. E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. O. E. Simmonds, F.R.Ae.S., M.I.Ae.E., M.A.

College of Aeronautical Engineering

Mr. C. R. Fairey, M.B.E., has joined the Advisory Council of the College of Aeronautical Engineering, Chelsea, in his capacity of President of the Society.

B.E.S.A. Committee on Fans

Mr. McKinnon Wood has been appointed the Society's representative to the B.E.S.A. Committee on Fans.

Czechoslovakian Aero Exhibition

Colonel the Master of Sempill has been appointed the Society's representative at the Czechoslovakian Aero Exhibition to be held in September-October, 1932.

Housing Scheme

Major D. H. Kennedy, O.B.E., F.R.Ae.S., was appointed the Society's delegate to a meeting of various engineering and technical societies, to discuss a general engineering building.

British Association

Mr. H. E. Wimperis, C.B.E., F.R.Ae.S., Vice-President, was appointed the Society's delegate for the Centenary Meeting of the British Association in September, 1931.

British Gliding Association

The Council have appointed the Past-President, Colonel the Master of Sempill, to act as their representative on the Council of the British Gliding Association for a further year.

Gifts of Photographs, Slides, Etc.

The Council wish gratefully to acknowledge the following:—

From Messrs. Trost Brothers, 47 photographs for the Society's collection, and a number of slides.

From Mr. C. R. Catesby, a very full collection of postcards and photographs of pilots and aircraft, covering the period 1912-1916.

From Mr. V. S. Gaunt, 53 slides of aircraft.

From Captain R. O. King, a copy of the group photograph of members of the Society.

From Captain F. L. M. Boothby, several albums containing a large and valuable collection of early airship and other photographs.

Donations to the Library

The Council gratefully acknowledge the following gifts to the Library:—

Bequeathed by the late Mr. Herbert Lloyd, an early French aeronautical engraving, a number of back issues of the Society's Journal and other early aeronautical publications, and a relic of the last glider of the late Percy Pilcher.

From Mr. E. G. Walker, several bound volumes of the Society's Journal, bound volumes of the Reports of the Advisory Committee for Aeronautics of Great Britain and the National Advisory Committee for Aeronautics, U.S.A., and a copy of the International Air Congress Report, 1923.

From Dr. Ing. Ph. Theodorides, Associate Fellow, Papers on Aeronautics, 1927-30, published in Athens, and a Paper on the Scientific and Technical Bases and Progress of Aeronautics, published in Athens.

From Mr. G. Tilghman Richards, a collection of private stress calculations of the War Period—a collection of great historical interest.

From Messrs. Trost Brothers, a number of interesting old German books and a number of aeronautical Press cuttings for 1925.

From Sir Robert Hadfield, copies of two of his papers, "A Research on Faraday's 'Steel and Alloys'" and "Notes on a Research regarding Faraday's 'Steel and Alloys.'"

From Colonel N. Belaiew, C.B., M.I.Ae.E., an old French coloured print, "Moyen infaillible d'enlever les Ballons."

The Council gratefully acknowledge gifts of back numbers of the Society's Journal from the following:—

Dr. E. G. Richardson.
Mr. M. H. Volk.
Mr. G. A. T. Stenning (and various other publications).
Mr. F. Walsh (and various other publications).
Mr. W. G. Gould.
Mr. H. R. Gillman.
Mr. T. B. Ringwood.
Mr. G. F. Rayner (and copies of "Aeronautics").
Mrs. Fullerton.
Mr. E. A. Skinner.
Mr F. R. B. King.

Contributions to the Journal

In response to inquiries from a number of members the Council will always be glad to consider contributions on any subject dealing with aeronautics or any of its allied subjects. The Council would like to impress upon all members that they should look upon the Journal as the proper place of publication of any original work which they may have done. The Journal circulates all over the world and is recognised to be the most authoritative publication of its kind now printed.

By supporting the Journal in this way members will make the Journal still more influential and will enable it to increase its already wide circulation, and in this way directly benefit the Society as a whole.

Membership Badges

For those members of the Society who wish to have them, a badge has been prepared. The badge shows the symbols of the Society, the peregrine and balloon, in finely chased gilt on a blue enamel background, surrounded by a royal blue border on which appears the lettering "The Royal Aeronautical Society, 1866." The badges have been hand made with the greatest care so that they will always retain their original appearance, and it is hoped that members will wear them on all suitable occasions. The price is 5/- or 5/3 post free.

Corrections

The following corrections should be made in the paper on "The Metalclad Airship," by Mr. Carl B. Fritsche:—

Page 859, line 35, should read: 8.20lbs. per sq. ft. or 1.57in. H_2O.

Page 860, line 30, should read:
$P\ (6{,}640{,}000 \times 2)/(3.14 \times 66^3) = 14.7$ lbs./sq. ft. $= 2.82$in. H_2O.

In the paper by Mr. H. C. H. Townend the following corrections should be made:—

Footnote, p. 711, should read in full "National Physical Laboratory, Aerodynamics Department. Reprinted from R. & M. 1394 by kind permission of the Aeronautical Research Committee."
p. 713, line 8, for slot read slat; line 27, for closed read close.
p. 714, line 30, for 11½in. read 10½in.
The title under Fig. 3 should read "Mean velocity of slot air resolved normal to arc $x = 0.02''$" shown — [·] —
Fig. 12, Table 5 (*a*), etc., should read Table II (*a*), etc.

In the correspondence from F./O. F. Whittle, which appeared in the March Journal, Figs. 1 and 3, on pages 261-262, should be transposed.

On page 1057, line 3, for " with which they come " read " with which it comes."

Page 1064, line 15, for " r.p.m. are well above the normal " read " r.p.m. are well below the normal."

Page 1070, below Table 6a (line 9) for " 232°abs." read " 323°abs."

In the paper by W. G. Bird:—

Page 980, line 44, " equation (vii) " should read " equation (vi)."

Page 986, line 32, " equation (xv) " should read " equation (xiv)."

Page 989, line 51, " feet " should read " metres."

Page 995, line 44, " 1.00056 " should read " 1.0056."

Page 997, lines 9, 20 and 21,

" K' for helium $= K\ (1 - .54\ r_0\pi_{T+t}/P)$."

" K' for hydrogen $= K'\ (1 + .58\ r_0\pi_{T+t}/P)$."

" K for helium $= K'\ (1 + .54\ r_0\pi_{T+t}/P)$."

Page 1002, line 18, for " then " read " these."

Page 1002, line 42, the expression for " Gross lift of airship " is " [(constant) × (pressure of air in mb.) × (percentage humidity factor)/(temperature of air in °A.) × 10^6] × Σ (gas volume in millions of cubic feet) × (percentage fulness) × (percentage dry purity) tons."

Page 1004, line 18, for " water " read " mercury."

Page 1012, line 16, for " equation (xxxiii) (*b*) " read " equation (xxxiv)."

Page 1020, line 29, " 5.256 " should read " 4.256."

Page 1024, line 20, " $p = 2TR$ " should read " $\rho = 2T/R$."

Page 1031, line 6, " $y = r \sin \alpha \cos \theta$ " should be " $y = r \sin \alpha \sin \theta$."

Page 1037, lines 25, 26, 37, 39, 42, 44, and page 1038, lines 4, 5 and 9, " $(T - t/T)$ " should read " $(T + t/T)$."

Obituaries

The Council have to record with deep regret the deaths of many of its members during the year, and to express their deep sympathy with their relatives.

William George Steven, *Student.*

William George Steven, a student of the Society, was a L.A.C. at Halton and joined the Society in July, 1930. Born on the 29th September, 1911, he had shown himself to be a most capable mechanic, and had obtained very high marks in the Halton examination. He was one of the crew of the flying boat disaster at Batten Bay, Plymouth, on February 3rd, 1931.

Beaumaris Woodward.

Beaumaris Woodward was for many years Honorary Solicitor to the Society. Mr. Woodward was elected a member of the Society at the Council meeting held on February 20th, 1911, and almost immediately it was recognised that in its new member the Society had someone of great energy and foresight. In October, 1911, Mr. Woodward was elected Honorary Solicitor to the Society and began immediately to draft up the Articles of Association for Aerial Science, Ltd. It was due to Mr. Woodward's far-sighted policy at that time that the Society was placed on a firm basis, and the Council feel that every member owes to him a deep debt of gratitude for work undertaken at a time when there appeared no real incentive for it to be undertaken. For nearly twenty years the advice of Mr. Woodward on all legal matters was very freely placed at the disposal of the Council, and during those years Mr. Woodward gave up much valuable time to straightening out, voluntarily, legal matters that came up for consideration.

Some two years ago Mr. Woodward was stricken with an illness which prevented him from taking an active part in the meetings of the Council, but up to the day of his death he took a keen interest in the Society's activities, and on many occasions expressed his deep regret that he was unable to attend the Society's functions. The Society, indeed, was his hobby and one which he rode with an enthusiasm tempered by a solid sense of values which commanded a respect for any views he put forward.

Beaumaris Woodward was born at Plumpton Rectory, Sussex, July 11th, 1855, the son of the Rev. William Woodward, whose ancestors had held the living in unbroken succession from the year 1600. After leaving Felstead he was articled to his brother-in-law to be trained as a solicitor, and on completing his articles spent some time in Canada and New York. In 1890 he began practice as a solicitor in the City of London.

Although in his 60th year at the outbreak of War he at once joined the Old Boys' Corps. The heavy physical work involved proved too much for him and he resumed his work as a solicitor, taking up a position in an office so that younger men could be released. In September, 1928, his health failed, and from that time until his death on June 14th, 1931, he was a complete invalid. Mr. Woodward leaves a widow and one daughter.

CHARLES RUMNEY SAMSON, *Associate Fellow*,
1883—1931.

Air Commodore Charles Rumney Samson, C.M.G., D.S.O., A.F.C., *Associate Fellow*, died suddenly on February 5th, 1931.

He was born at Cheetham, Lancashire, and entered the Royal Navy in 1898, serving in the Somaliland Operations of 1903-4 and the Operations in the Persian Gulf in 1909-10. In 1911, when Mr. (now Sir Francis) Frank McClean offered to provide facilities to naval officers who wished to fly, Samson was one of the four officers chosen by the Admiralty to take a course at Eastchurch.

From the beginning Samson showed the keenness in the air he had shown at sea. He took the Royal Aero Club's certificate in April, 1911, and in the October of that year was successful in persuading the Admiralty to form a flying school at Eastchurch. Shortly afterwards he made a flight from the deck of H.M.S. *Africa*, the first of its kind in Europe. In those early days Samson had the vision that aircraft would be the dominating weapon of war of the future.

In 1911-12 he was a member of the Technical Sub-Committee which prepared a scheme for the formation of the Royal Flying Corps, and early in 1912 he took over the new Naval Flying School at Eastchurch, where he carried out some of the earliest experiments with bomb dropping and wireless. He was in command of the Naval Air Unit which flew to Ostend on August 10th, 1914, and under his command the flight carried out reconnaissance flights and made the first night-flying of the War. The story of the Eastchurch Squadron and its adventures, before it was withdrawn from Dunkirk in 1915, is told in Samson's book, "Flight and Fights." For his work with the squadron he was promoted to Commander by the Admiralty, received the D.S.O., the *Croix de Guerre* and was made a Chevalier of the Legion of Honour.

In March, 1915, Samson was placed in command of No. 3 wing and took part in the Dardanelles adventure. Following the end of the Gallipoli campaign, he took command of the converted Isle of Man packet boat, H.M. Aircraft Carrier *Ben-my-chree*, from April, 1916-June, 1917. The ship was destroyed by Turkish gunfire in the harbour of Castellorizo, and Samson was appointed to the command of the *Raven II*, and scoured the Indian Ocean with seaplanes in search of submarines. For his work he was awarded a bar to his D.S.O.

In November, 1917, Samson took over the command of the Naval Air Station at Great Yarmouth, and in October, 1918, that of the group at Felixstowe, and in January, 1919, he received the Air Force Cross for his experimental work in

flying aircraft from lighters towed behind destroyers. A Wing Commander on the formation of the R.A.F., he was promoted a Group Captain in August, 1919, and Air Commodore in January, 1921. Immediately following the War he was Chief Staff Officer at Headquarters, Coastal Area, and in 1921 took over the command of the R.A.F. in the Mediterranean. In 1926 he commanded the service flight of Vickers Victorias which flew from Heliopolis to Aden and back, and in 1927 the service flight of Fairey III F.'s from Cairo to Cape Town and back. In the August of that year he was placed on the half-pay list, and in November, 1929, on the retired list.

With the retirement of Air Commodore Samson the Royal Air Force lost one of its most adventurous spirits. In the flying game from the very beginning he became a leader. No enterprise was so hazardous, no adventure so uncertain in its end, but Samson was in it as its leader. He was essentially a great leader in the older sense, but he was too impatient when it came to the organisation and administration which is necessary in the higher ranks of the fighting forces. But for that impatience Air Commodore C. R. Samson would have had open to him the highest rank in the Royal Air Force, for in many ways he was a genius and far-sighted, and had an energy, a will to conquer difficulties—as shown by his many improvisations before and during the War—which would have been of the utmost value.

To Charles Rumney Samson the Royal Air Force owes much, and not the least that he embodied that spirit of adventure without which the Royal Air Force cannot exist.

EDMOND F. B. BOURNE, *Companion.*

Edmond F. B. Bourne, who died at Parkstone, Dorset, on June 19th, 1931, at the age of 66, had been a Companion of the Society since 1918.

PROFESSOR ARCHIBALD BARR, *Fellow.*

Professor Barr, who was elected a Fellow of the Society in 1919, died on August 5th, 1931, in his 76th year. He was the Emeritus Professor of Civil Engineering and Mechanics at Glasgow University and took a lively interest in aviation. He was the first President of the Scottish Branch of the Royal Aeronautical Society.

WILLIAM LLOYD SHIERS, *Associate Member.*

William Lloyd Shiers died on August 4th, 1931, at Johannesburg, as the result of an accident, at the early age of 27. He was a very keen member, a member of the Johannesburg Light Plane Club and kept in close touch with the Society, constantly doing all he could to draw the attention of potential members in South Africa to the Society.

MAJOR J. C. B. FIRTH, *Companion.*

Major Firth, who died at Blyth, Nottinghamshire, at the early age of 37, was keenly interested in aviation, and by his death aeronautics and the Society lost one of their most enthusiastic supporters.

LEIGHTON ANGUS, *Companion.*

Leighton Angus was born in New South Wales, Australia, in 1905, and came to England in 1911 to the Priory, Malvern, and afterwards to Malvern College. Afterwards he took a course in aeronautics at the London University and devoted the whole of his time and energy to the study of aeroplane design and construction. He decided to build a small experimental aeroplane to demonstrate a method of construction he had developed. The machine was built at Hamble, Southampton, and he was afterwards killed at Hanworth, on March 21st, while making an experimental flight.

Leighton Angus was one of those rare enthusiastic spirits whose death is a real loss to aviation.

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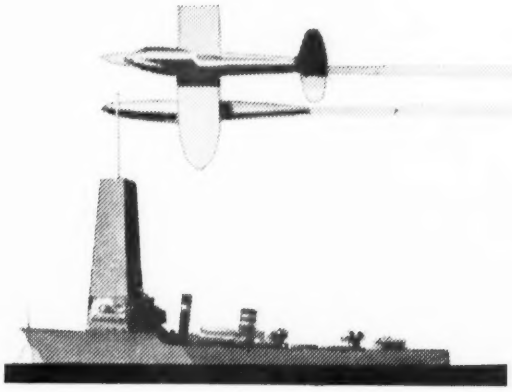
Annual Meteorological Report.



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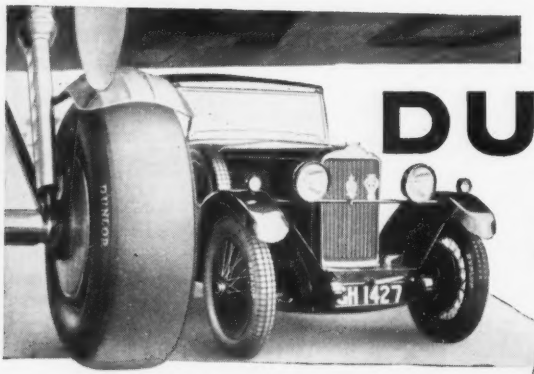

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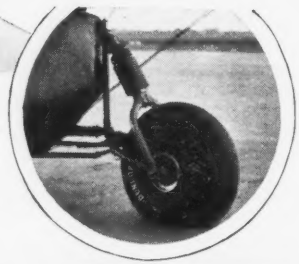

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THE
ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES
JANUARY 1931

Endowment Fund Appeal

At Christmas, 1930, an appeal was circulated to all members for the Endowment Fund of the Royal Aeronautical Society. The whole of the heavy expenses of this appeal has been borne by the President, Mr. C. R. Fairey. Without the generous help Mr. Fairey immediately offered when the question of the appeal came before the Council for consideration, it would not have been possible to make it in the form it has been made, despite the urgency of raising the Endowment Fund. The Council wish to impress upon all the members of the Society that, to quote from the appeal, " the real value of the Society's work must always depend on the energy, the loyalty and the mutual co-operation of its officers and members."

Every member can help, not only by contributing within his or her means to place the Society on a satisfactory financial footing, but by drawing the attention of all, who may not be members of the Society but who are interested in the cause of aviation, to the appeal and to the work which the Society is doing.

A society which has numbered among its members such well-known pioneers as James Glaisher, F. M. Wenham, John Stringfellow, Horatio Phillips, Percy S. Pilcher and Otto Lillienthal, must progress.

In the list of Honorary Fellows appears the name of Patrick T. Alexander, who has given so much to aviation. In the list appear also two names, Dr. F. W. Lanchester and Professor L. Prandtl, to whom aviation of to-day owes its very foundation stone, in the Lanchester-Prandtl theory. To quote from the President's address on the delivery of the Wilbur Wright Memorial Lecture, May, 27th, 1926, " No prophet is honoured in his own country, and we may well be ashamed that British scientists did not follow up Dr. Lanchester's work with vigour and appreciation. Joukowski and Prandtl, however, made full use of his work. Prandtl began in 1910 and by the end of the war had stabilised Lanchester's vortex theory by practical experiment." It was on this day that Dr. Lanchester was awarded the Gold Medal of the Society, the highest honour in the world which is awarded for accomplishment in aeronautical science.

To-day the leaders in every branch of aviation are members of the Society, and it is safe to say that whatever progress is being made, scientific, industrial or otherwise, is due in a very large measure to those who are members of the oldest aeronautical society.

Greater progress, however, would be made, if the Council had at their disposal a secure income which would enable them to legislate ahead for the obtaining and printing of information, and for carrying out other schemes for which there has been a crying need for some years. It is for these purposes, as well as for those outlined in the appeal, that every possible help which can be given should be given *now*.

Canadian Branches

On the occasion of his visit to Canada in June and July, 1930, the Secretary had an opportunity of discussing with prominent members of the Society the possibility of forming branches of the Society in Canada. The Secretary found that in Canada the Engineering Institute of Canada includes in its membership all branches of the profession. The wide geographical area over which the members of the institute are scattered involved an organisation on a decentralised basis. There is a headquarters office in Montreal and some twenty-five branches which in themselves are the equivalents of local technical societies, and have been given powers to form sections of the various specified branches of engineering.

The organisation of these sections corresponds very closely to that of the branches of the Royal Aeronautical Society. The Secretary had considerable discussion with the Secretary of the Engineering Institute of Canada and with members of the Council, and a provisional agreement was drawn up by which aeronautical sections of the Institute are being formed which will also be Canadian sections or branches of the Royal Aeronautical Society. This agreement has now been ratified by the Councils of both bodies and will be published in the next issue of the Journal.

One of the outstanding features of the agreement is an interchange of publications, so that the British point of view will regularly and systematically be presented to those interested in aviation in Canada, and the progress of Canadian aviation will, in a similar way, be regularly placed before every member of the Society.

The Council wish to extend to all members in Canada who helped the Secretary on his visit their very grateful thanks not only for that help, but for the extremely great welcome and facilities they gave him in the course of his inquiries. The Council wish, too, to take this opportunity of thanking the Secretary of the Engineering Institute of Canada and members of Council of that body for their willing co-operation and for the great amount of time and energy they gave to the discussions with Captain Pritchard. Without the help and guidance of the Institute it would have been difficult, if not impossible, to have formed branches of the Society in Canada.

In the Secretary's report on his visit an opportunity will occur to thank by name those who helped, but here the Council wish to make public acknowledgment at the earliest opportunity following the signing of the agreement between the two bodies.

Council Meeting

A Meeting of Council was held on Tuesday, December 16th, 1930. Present: In the chair, Mr. C. R. Fairey, President; Captain P. D. Acland, Mr. M. L. Bramson, Mr. Griffith Brewer, Major G. P. Bulman, Major D. H. Kennedy (Hon. Treasurer), Colonel the Master of Sempill (Past-President), Mr. H. E. Wimperis (Vice-President), Mr. L. A. Wingfield (Hon. Solicitor).

Among the business transacted was the following:—The Endowment Fund Appeal; the R.101 disaster; the Report of the Finance Committee; the Report of the Grading Committee; a recommendation from the Education Committee; representation on the Segrave Memorial Fund Awards Committees.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on December 16th, 1930:—

Associate Fellows.—Rupert Beaney, John Dunbar Blyth, Ernest Edward Chatterton, Frank Duncanson, Donald Lister, Thomas Tanner (from Student), Montague Sidney William Templeman (from Student).

Associate Member.—Charles Snow.
Associates.—Robert Limbert Carter, John Athelstan Victor Nisbet, Roger Lovett Nowland, Reginald Reynolds, Walter Ernest Vick.
Students.—George Bernard Dwyer, Eric Malcolm Gibbs, Stanley George Hooker, William John Claude Humphrey, Arthur Edwin Smith, Clifford H. Jackson, Richard Henry Mead, William Halse Paine, Gordon Thripp.
Companion.—John Harold Edge.

Acknowledgments

The Council wish gratefully to acknowledge from Messrs. Trost Brothers 47 photographs for the Society's collection, two books of aviation press cuttings for 1925, and a number of lantern slides.

The Council also wish to acknowledge from Mr. C. R. Catesby a very full collection of postcards and photographs of pilots and aircraft covering the period 1912-1916. This collection is one of remarkable interest covering, as it does, a period of such great importance in the development of flying.

The Council further wish to acknowledge a number of back issues of the Journal from Dr. E. G. Richardson.

Promotions and Honours

The following promotions of members were announced on January 1st:—

Air Vice-Marshal to be Air Marshal: Sir Robert Brooke-Popham, K.C.B., C.M.G., D.S.O., A.F.C.

Air Commodore to be Air Vice-Marshal: Felton Vesey Holt, C.M.G., D.S.O.

Flying Officers to be Flight Lieutenants:
William George Kentfield, A.M.I.Ae.E.
Archibald Henry Harrison, D.S.M., A.M.I.Ae.E.

The following has received the Order of the British Empire:—

R. S. Capon, B.A., F.R.Ae.S., Superintendent of Scientific Research, Royal Aircraft Establishment.

The Aeronautical Diary, 1931

The Aeronautical Diary for 1931 has just been published by Messrs. Gale and Polden. For those who are members of the Society, the diary is obtainable with the Society's crest on it in gold. The diary contains very full information of aeronautical bodies, flying clubs, civil flying schools, aircraft and aero engine manufacturers, commercial and light aircraft, aero engines, notes on licensing private pilots, air touring facilities, air stations, air records and aircraft making, as well as tables and other information of interest to airmen, forthcoming lectures, etc. It is hoped that every member of the Society will buy a copy of the diary, for by buying it every member is directly helping the Society, as a percentage of the profits from all copies sold is being given by the publishers to the Endowment Fund. The prices of the diary are as follows:—Bound in blue cloth, without loop and pencil, 1s. 6d. net; in blue cloth, with loop and pencil, 2s. net; in royal blue leather, with loop and pencil, 3s. net; in refill form in solid blue morocco leather wallets, 7s. 6d.

Applications for the Aeronautical Diary should be made direct to Messrs. Gale and Polden, Aldershot, and not to the offices of the Society.

Elliott Memorial Prize

The Elliott Memorial Prize for the half-year ending December 31st, 1930, was awarded to L. A. A. G. J. Armstrong, who had the highest marks in the General Studies Paper of the final passing-out examination of the January, 1928, entry.

Lecture Programme

The following lectures have been arranged for the second half of the 1930-31 Session :—

January 8th.—" Some Aspects of the Design and Construction of Sea-Going Aircraft." Mr. A. Gouge, B.Sc., A.F.R.Ae.S.

January 22nd.—" Deck Flying." Squadron Leader W. R. D. Acland, D.F.C., A.F.C.

January 29th.—" Development and Construction of Sailplanes and Gliders." Herr A. Lippisch.

February 12th.—" Air Navigation." Capt. N. Macmillan, M.C., A.F.C., A.F.R.Ae.S. (Joint Meeting with the Guild of Air Pilots and Air Navigators.)

February 26th.—" Meteorological Aspects of Gliding and Soaring." Capt. F. Entwistle, B.Sc. (Joint Meeting with the British Gliding Association.)

March 19th.—" Research in the Berlin Technische Hochschule." Dr. W. Hoff.

April 16th.—" Aircraft Noise." Dr. A. H. Davis.

April 30th.—" Aerodynamics of Sails." Dr. Manfred Curry.

May 14th.—" The Metal-Clad Airship." Mr. Carl Fritsche.

All meetings will take place at the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

The dates of further lectures will be announced later.

Subscriptions of Members

Members are reminded that all annual subscriptions became due on January 1st. The rates are :—

	Home.			Abroad.		
	£	s.	d.	£	s.	d.
Fellow	4	4	0	3	3	0
Member	4	4	0	3	3	0
Associate Fellow	3	3	0	2	2	0
Associate Member	3	3	0	2	2	0
Associate	*2	2	0	*2	2	0
Student	1	1	0	1	1	0
Companion	2	2	0	2	2	0
Founder Member	2	2	0	2	2	0

* £1 1s. 0d. without Journal.

Forthcoming Events

January 8th.—" Some Aspects of the Design and Construction of Sea-Going Aircraft." Lecture by Mr. A. Gouge, B.Sc., A.F.R.Ae.S., before the Society in the Lecture Hall of the Royal Society of Arts, at 6.30 p.m.

January 8th.—Yeovil Branch. " Aircraft Production Methods in America." Mr. R. A. Bruce.

January 16th.—Manchester Branch. " The Practical Lubrication of Aircraft Engines." Messrs. Shell Mex, Ltd.

January 22nd.—" Deck Flying." Lecture by Squadron Leader W. R. D Acland, D.F.C., A.F.C., before the Society in the Lecture Hall of the Royal Society of Arts, at 6.30 p.m.

January 22nd.—Yeovil Branch. " Model Aeroplanes." Mr. W. Rigby.

January 29th.—" Development and Construction of Sailplanes and Gliders." Lecture by Herr A. Lippisch, before the Society in the Lecture Hall of the Royal Society of Arts, at 6.30 p.m.

January 29th.—Yeovil Branch. " Machining and Working of Stainless Steel." Mr. R. Waddell.

January 30th.—Hull and Leeds Branch. " Gliding and Soaring." Colonel the Master of Sempill.

J. LAURENCE PRITCHARD, *Secretary*.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

FEBRUARY 1931

Endowment Fund Appeal

A number of contributions have been received, in response to the Endowment Fund appeal, circulated at Christmas, 1930, and will be acknowledged in due course in the Journal. The President and Council are aware that the appeal was circulated at a time when the outlook was not over optimistic, but they were confident that a full realisation by the members of the position of the Society would result in a generous response.

The first object of the fund is to place the Society's finances on such a basis that it has an assured income to enable it to provide members with properly co-ordinated information on all branches of aviation. The Council wish every member to look to the Society to provide technical information, and to get in the habit of consulting the Society first, before trying other sources. But the cost of co-ordinating such information, of printing and indexing it, is heavy. The second object of the fund is to provide a building, in keeping with the prestige of the Society, to house its valuable library.

It is not fully realised that the income of the Society from its members and investments is nearly £1,000 a year less than the present expenditure. The percentage of overhead charges of the total income, including salaries, etc., has decreased very considerably during the past five years, but there has been a steady increase in printing costs, the cost of the library and the like in an effort by the Council to increase lectures and information for the benefit of members. This deficit of expenditure over income is at present largely made up by generous contributions of £250 each a year from the Air Ministry, the Society of British Aircraft Constructors and the Society of Motor Traders and Manufacturers. But these contributions cannot be considered to be permanent in any way and when they are no longer available the Society may be compelled to curtail many of its activities, instead of extending them.

Every possible help which can be given should be given *now*.

Council Meeting

A Meeting of Council was held on Tuesday, January 20th, 1931. Present: In the chair, Mr. C. R. Fairey, President; Captain P. D. Acland, Major T. M. Barlow, Mr. M. L. Bramson, Major G. P. Bulman, Wing Comdr. T. R. Cave-Browne-Cave, Captain F. T. Hill, Major D. H. Kennedy (Hon. Treasurer), Captain A. G. Lamplugh, Mr. W. O. Manning, Lieut.-Colonel J. T. C. Moore-Brabazon (Vice-President), Colonel the Master of Sempill (Past-President), Mr. H. E. Wimperis (Vice-President) and Mr. L. A. Wingfield (Hon. Solicitor).

Among the business transacted was the Endowment Fund Appeal; the Report of the Finance Committee; the Report of the Grading Committee; the Handbook of Aeronautics; and the Wilbur Wright Memorial Lecture.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on January 20th, 1931:—

Fellows.—Glenn L. Martin, Holden Chester Richardson.

Member.—Francis McKenna.

Associate Fellows.—Frank Gordon Evans (from Student), Alexander Lippisch.

Associate Member.—Mostafa Riad Moursi.

Associate.—Ovid Ottley.

Students.—Joseph Ronald Barnard, Sydney James Cater, Colin James Craig Ewing, Christopher John Reming, Louis Levy, Geoffrey Peter Kirk, William Henry Lewis, Wallace Eric Locke, Geoffrey Alexander McMillan, James Ernest Raddings, Albert Cyril Shaw, Rex Watson.

Companion.—Temple Gerald Arnele Stenning (from Student).

Lecture Programme

The following two lectures have been arranged, in addition to those already announced:—

March 12th.—"Night Air Mails," by Captain Carl Florman. A joint meeting with the Institute of Transport.

March 31st.—A joint meeting with the Institution of Automobile Engineers on "High Speed Heavy Oil Engines."

Subscriptions of Members

Members are reminded that all annual subscriptions became due on January 1st. The rates are:—

	Home.			Abroad.		
	£	s.	d.	£	s.	d.
Fellow	4	4	0	3	3	0
Member	4	4	0	3	3	0
Associate Fellow	3	3	0	2	2	0
Associate Member	3	3	0	2	2	0
Associate	*2	2	0	*2	2	0
Student	1	1	0	1	1	0
Companion	2	2	0	2	2	0
Founder Member	2	2	0	2	2	0

* £1 1s. 0d. without Journal.

The attention of all members is drawn to Rule 70, which reads as follows:—

> "Any Fellow, Member, Associate Fellow, Associate Member, Associate, Student, Companion, or Founder Member, whose subscription shall not have been paid before the first day of April, shall be in arrears of subscription and shall not be entitled to attend or vote at any meeting or to receive any publications to which he would otherwise be entitled."

Under this Rule no Journals are sent to members whose subscriptions are still outstanding on April 1st. The Council hope that every member will realise fully the importance of paying his subscription as promptly as possible, as it is not practicable to supply back numbers of the Journal to those whose subscriptions are outstanding for any length of time.

Forthcoming Events

Tuesday, February 3rd.—Lecture before the Manchester Branch. "The Evaporative Cooling of Aero Engines." Mr. Ellor.

Thursday, February 5th.—"American and Canadian Aviation." Lecture by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., before the Bristol Branch.

Thursday, February 5th.—Lecture before the Gloucester and Cheltenham Branch. "Address to Ground Engineers." Mr. Mirams.

Thursday, February 5th.—Lecture before the Yeovil Branch. "Westland Wapiti in Australia." Squadron Leader C. T. Anderson, D.F.C.

Tuesday, February 10th.—Students' Section Meeting, at 6.30 p.m., in the Library of the Society. Paper to be read by Mr. S. G. Hooper on "The Effects of Compressibility on High Speed Flight."

Wednesday, February 11th.—Students' Joint Meeting with City and Guilds' Engineering Society, at City and Guilds' Engineering College, at 5.15 p.m. Lecture by Professor L. Bairstow on "Streamlining."

Thursday, February 12th.—"Air Navigation." Lecture by Captain N. MacMillan, M.C., A.F.C., A.F.R.Ae.S., before the Society in the Lecture Hall of the Royal Society of Arts, at 6.30 p.m. A joint lecture with the Guild of Air Pilots and Air Navigators.

Thursday, February 12th.—Lecture before the Gloucester and Cheltenham Branch. "Magnetos." Mr. Schobel.

Thursday, February 12th.—Lecture before the Yeovil Branch. "Spinning." Mr. S. Scott-Hall, A.F.R.Ae.S.

Thursday, February 19th.—Lecture before Gloucester and Cheltenham Branch. "Heat Treatment of Steels." Mr. A. L. Williams, B.Sc., A.M.I.Mech.E.

Thursday, February 19th.—Lecture before the Yeovil Branch. "Lay-out and Equipment of Service Aircraft." Squadron Leader R. B. Sorley, D.S.C., D.F.C.

Tuesday, February 24th.—Lecture before the Manchester Branch. "Machine Tools." Messrs. Alfred Herbert, Ltd.

Thursday, February 26th.—"Meteorological Aspects of Gliding and Soaring." Lecture by Captain F. Entwistle, B.Sc., before the Society in the Lecture Hall of the Royal Society of Arts, at 6.30 p.m. A joint lecture with the British Gliding Association.

Thursday, February 26th.—Lecture before the Gloucester and Cheltenham Branch. "Motor Fuels and Modern Methods of Testing." Anglo-American Oil Co.

Thursday, February 26th.—Lecture before the Yeovil Branch. "Latest Aircraft Instrument Developments." Major C. J. Stewart, O.B.E., F.R.Ae.S.

Friday, February 27th.—Lecture before the Hull and Leeds Branch. "Aircraft Light Alloys." Mr. H. Sutton, M.Sc., A.F.R.Ae.S.

J. Laurence Pritchard, *Secretary.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

MARCH 1931

Annual General Meeting

The Annual General Meeting of the Society will be held in the Library on Monday, March 30th, 1931, at 6.30 p.m. The statement of accounts for the year ending December 31st, 1930, and the Council's Annual Report for the year will be presented. Tea will be served to members attending the meeting.

At the Annual General Meeting the Council will put forward an alteration of Rule 86 to read as follows: " One-half of the Council (excluding the President and the immediate Past-President if a member of Council) shall retire annually. The members who shall retire shall be those longest in office, except as provided in Rule 92. Retiring members of Council who have served for two terms in succession (four years) shall not be eligible for re-election until the next annual election, when they will be eligible."

Under the present Rule members of Council can offer themselves for re-election no matter how long they have served. Under the proposed new rule a member of Council who has served for four years consecutively will not be eligible for election for twelve months, when he can again stand.

Nominations to Council

Nominations for election to the vacancies on the Council, signed by two voters and accompanied by a statement signed by the candidate signifying his willingness to serve if elected, must be received by the Secretary not later than Monday, March 9th, 1931.

Endowment Fund Appeal

In the annual report of the Council is given a preliminary list of names of those who have contributed to the Endowment Fund appeal which was recently circulated. It is hoped that every member will consider carefully the ultimate benefit which a substantial Endowment Fund will bring to him. The income from the Endowment Fund will not only enable the Council to carry out in a more intensive way the objects of the Society, but it will, when it has reached a proper amount, lower the subscriptions, and enable the Society to acquire its own premises, where it can house in a becoming way its collection of books, and possess its own lecture hall.

The President and Council are well aware that the present time is not one of great optimism, but it is in times of pessimism that the greatest efforts should be made. He gives twice who gives quickly. The future of the Society lies in the hands of its members.

Every member probably knows someone interested in the progress of aviation who might, if suitably approached, be prepared to help. If he will send the names of anyone to the President or the Secretary a copy of the appeal will be forwarded.

Council Meeting

A meeting of Council was held on Tuesday, February 17th, 1931. Present: In the Chair, Sir Vyell Vyvyan, Vice-President; Captain P. D. Acland; Major T. M. Barlow; Major G. P. Bulman; Mr. Griffith Brewer; Wing Commander T. R. Cave-Browne-Cave; Captain F. T. Hill; Major D. H. Kennedy, Hon. Treasurer; Captain A. G. Lamplugh; Mr. W. O. Manning; Colonel the Master of Sempill, Past-President; Mr. L. A. Wingfield, Hon. Solicitor.

Among the business transacted was the representation of the Society at the coming Swedish Aero Exhibition; the Endowment Fund Appeal; the report of the Finance Committee; the report of the Grading Committee; the Annual General Meeting; alteration of Rule 86; and appointment of a representative of the Society on the Council of the British Gliding Association.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on Tuesday, February 17th, 1931:—

Member.—Alan Theodore Eden Eadon (from Assoc. Member).

Associate Fellows.—Senr. Juan de la Cierva, William Crane Cunnington, Alfred Lancelot Dimmock, Pierre Victor Lamarque, William Alban Tamblin, Wing Commander George William Williamson.

Associates.—George Walter Arthur Allen, Thomas Henry Blake, Frederick John Dean, James Bernard Terence Whitehead.

Students.—Sydney Allard, Bernard Horace Becker, Frederick Clifford Bertram, Terence Michael Anthony Donlea, Hugh Evans, Ronald John Fyfe, Neville Durrant New, John Henry Payne, William Edward Willoughby Petter, Frank Squire, William Thomas Wakeham, Edwin James Weeks.

British Gliding Association

The Council have appointed the Past-President, Colonel the Master of Sempill, to act as their representative on the Council of the British Gliding Association.

Subscriptions of Members

Members are reminded that all annual subscriptions became due on January 1st. The rates are:—

	Home. £ s. d.	Abroad. £ s. d.
Fellow	4 4 0	3 3 0
Member	4 4 0	3 3 0
Associate Fellow ...	3 3 0	2 2 0
Associate Member ...	3 3 0	2 2 0
Associate	*2 2 0	*2 2 0
Student	1 1 0	1 1 0
Companion	2 2 0	2 2 0
Founder Member ...	2 2 0	2 2 0

* £1 1s. 0d. without Journal.

The attention of all members is drawn to Rule 70, which reads as follows:—

"Any Fellow, Member, Associate Fellow, Associate Member, Associate, Student, Companion, or Founder Member, whose subscription shall not have been paid before the first day of April, shall be in arrears of subscription and shall not be entitled to attend or vote at any meeting or to receive any publications to which he would otherwise be entitled."

Under this Rule no Journals are sent to members whose subscriptions are still outstanding on April 1st. The Council hope that every member will realise fully the importance of paying his subscription as promptly as possible, as it is not practicable to supply back numbers of the Journal to those whose subscriptions are outstanding for any length of time.

Donations

The Council wish gratefully to acknowledge the gift of several bound volumes of the Journal, bound volumes of the Reports of the Advisory Committee for Aeronautics and the N.A.C.A. report and a copy of the International Air Congress Report, 1923, from Mr. E. G. Walker.

The Council also wish to thank Mr. M. H. Volk for the gift of back numbers of the Journal.

Forthcoming Events

March 3rd.—Students' Section. "The Contribution of the Glider to Aerodynamics," by Mr. W. S. Coleman.

March 5th.—Gloucester and Cheltenham Branch. "Mechanical Testing of Aircraft Materials," by Mr. L. W. Nethercott, A.R.Ae.S.I.

March 10th.—Students' Section. "Seaplane Floats," by Mr. R. O. Passmore.

March 12th.—Lecture before the Society by Mr. Carl Florman on "Night Flying." 6.30 p.m. at the Royal Society of Arts. (Joint meeting with the Institute of Transport).

March 12th.—Yeovil Branch. "Metals," by Mr. W. K. Norton, A.I.D.

March 19th.—Lecture before the Society by Dr. W. Hoff on "Research in the Berlin Technische Hochschule." 6.30 p.m. at the Royal Society of Arts.

March 27th.—Hull and Leeds Branch. "The Flying of High-speed Seaplanes," by Squadron-Leader A. H. Orlebar, A.F.C.

March 30th.—Annual General Meeting in Library of the Society at 6.30 p.m.

March 31st.—Joint Meeting with the Institution of Automobile Engineers and other bodies. Lecture by Dr. S. J. Davies, Ph.D., M.Sc., M.I.Mech.E., and Mr. E. Griffen, M.Sc., A.M.I.Mech.E., on "Injection, Ignition and Combustion in High-speed Heavy-oil Engines." 7.45 p.m. in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1.

J. LAURENCE PRITCHARD, *Secretary.*

OBITUARY

WILLIAM GEORGE STEVEN, *Student*

It is with very great regret that the Council have to record the death of William George Steven, a student of the Society. Steven was a L.A.C. at Halton and joined the Society in July, 1930. Born on the 29th September, 1911, he had shown himself to be a most capable mechanic, and had obtained very high marks in the Halton examination. He was one of the crew of the flying boat disaster at Batten Bay, Plymouth, on February 3rd, 1931. The Council wish to express their condolences with the family of Mr. Steven in their heavy loss.

THE
ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

APRIL 1931

Endowment Fund Appeal

For the last twelve months there has been one inviolable item on the agenda of the Finance Committee, "To consider the Endowment Fund Appeal." Twelve months ago the Finance Committee passed a resolution that the Endowment Fund should be considered every month as automatically as another item on the agenda, "To consider bills payable." And these two items are considered each month by the Council.

In this way the Council and the Finance Committee will have the Endowment Fund not only continually before them, but they will have linked with it "*Bills Payable.*" The two are indissolubly linked. There are two ways of looking at the latter item. One is to increase it and the other to decrease it. To cut down expenses means many serious things, the cutting down of the work of the Society, a decrease in its JOURNAL, a decrease in its lectures, a decrease in papers printed, among others. Nothing could be more disastrous. To keep in the air one must think and continually put forth energy to prevent oneself falling. The considered policy of the Council is to increase the *Bills Payable, e.g.*, to enlarge the scope of the JOURNAL, to increase the number of papers printed, to disseminate information on a wider basis each year, to build up a library and index of technical information which is unique, to make the Society pre-eminently the leading society of its kind throughout the world.

And here the Endowment Fund becomes important. The Society, at present, is enabled to carry on and progress largely through the generous grants which have been made to it year by year by outside bodies. Nevertheless, in the long run, it is upon the energies of its own members that the Society must rely for its continued prosperity and progress.

In the list of donations to the Endowment Fund which has already been published, there appear many names of those who are not members of the Society, one is almost tempted to say a larger proportion than should be the case.

Endowment Fund Appeal Acknowledgments

	£	s.	d.
Already acknowledged	352	4	6
Oliver Thorneycroft, Esq., O.B.E., A.F.R.Ae.S.	1	0	0
Rubery, Owen and Co.	10	10	0
Woods, Sons and Co.	5	5	0
James C. Nicklin, Ltd.	5	0	0
London Label Co., Ltd.	2	2	0
The International Zeppelin Transport Corporation	25	0	0
E. V. Dolby, Esq., Comp., R.Ae.S.I.	1	1	0
Farmer Stedall and Co.	10	10	0
F./O. L. T. Pankhurst, A.M.I.Ae.E.	0	10	0
Osborne, Stevens and Co., Ltd.	5	5	0
Wing Cmdr. H. Blackburn, M.C., A.F.C., A.F.R.Ae.S. ...	0	10	6
R. F. Dagnall, Esq.	3	3	0
Capt. H. F. Jackson (Founder Member)	1	1	0
C. E. T. Maguire, Esq., Comp., R.Ae.S.I.	0	10	6
M. W. Wood, Esq., A.F.R.Ae.S.	0	10	6
Norman B. Scott, Esq., Stud., R.Ae.S.I.	0	10	0
Messrs. C. Lindley and Co., Ltd.	5	5	0
R. A. Chalmers, Esq.	10	10	0
F. R. B. King, Esq., Stud., R.Ae.S.I.	1	1	0
The British Gliding Association	10	0	0
Flt.-Lt. R. A. Seaton, A.F.R.Ae.S.	1	1	0
Dunlop Rubber Company	105	0	0
Total acknowledged (Appeal)	£549	10	0

The total amount of the fund is now £1,827 os. od.

Council

There were ten nominations to the ten vacancies on the Council, so that the necessity for an election did not arise. The following is the Council for the year April, 1931—March, 1932:—

President:

Mr. C. R. Fairey, M.B.E., F.R.Ae.S.

Past-President:

Colonel the Master of Sempill, A.F.C., F.R.Ae.S.

Vice-Presidents:

Air Vice-Marshal Sir Vyell Vyvyan, K.C.B., D.S.O.
Lieut.-Col. J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.I.Ae.E.
Mr. H. E. Wimperis, C.B.E., F.R.Ae.S.
Prof. L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.

Council:

Captain P. D. Acland.
Major T. M. Barlow, M.Sc. (Eng.), M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. Robert Blackburn, O.B.E., Assoc.M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., M.I.Ae.E.
Mr. M. L. Bramson, A.C.G.I., F.R.Ae.S., M.I.Ae.E.
Mr. Griffith Brewer, F.R.Ae.S.

Major J. S. Buchanan, O.B.E., A.M.I.Mech.E., F.R.Ae.S.
Major G. P. Bulman, O.B.E., B.Sc., A.F.R.Ae.S.
Mr. A. H. Hall, C.B.E., M.Inst.C.E., M.I.Mech.E., A.F.R.Ae.S.
Captain F. T. Hill, F.R.Ae.S., M.I.Ae.E., B.Sc., Wh. Ex.
Captain A. G. Lamplugh, F.R.Ae.S., M.I.Ae. E.
Mr. M. Langley, A.M.I.Ae.E., A.M.Inst.N.A.
Mr. W. O. Manning, F.R.Ae.S.
Lieut.-Col. F. C. Shelmerdine, O.B.E., A.F.R.Ae.S.
Mr. A. F. Sidgreaves, O.B.E.
Mr. L. A. Wingfield, M.C., D.F.C., A.R.Ae.S.I.
Mr. R. McKinnon Wood, O.B.E., M.A., Assoc.M.Inst. C.E., F.R.Ae.S.

Hon. Treasurer:
Major D. H. Kennedy, O.B.E., F.R.Ae.S.

Hon. Librarian:
Mr. J. E. Hodgson.

Hon. Solicitor:
Mr. L. A. Wingfield, M.C., D.F.C., A.R.Ae.S.I.

Hon. Accountant:
Mr. A. N. D. Smith, F.I.C.A.

It should be noted that the President, Past-President and Vice-Presidents take office as from October-September.

Council Meeting

A meeting of Council was held on Tuesday, March 17th, 1931, in the Offices of the Society.

Present: Mr. C. R. Fairey (President) in the chair; Captain P. D. Acland, Professor L. Bairstow (Vice-President), Major T. M. Barlow, Mr. R. Blackburn, Mr. M. L. Bramson, Mr. Griffith Brewer, Major G. P. Bulman, Captain F. T. Hill, Captain A. G. Lamplugh, Mr. W. O. Manning, Colonel the Master of Sempill (Past-President), Mr. C. C. Walker, Mr. L. A. Wingfield (Hon. Solicitor).

Among the business transacted was:—The Endowment Fund, the Report of the Finance Committee; the Annual Report and Accounts; the Report of the Grading Committee; an Interim Report of the Education and Examinations Committee.

Donations and Acknowledgments

The Council wish gratefully to acknowledge the following:—

From Mr. G. A. T. Stenning, a set of Journals for 1926-30 and a number of odd Journals, R. & M.s, reports and various aeronautical publications.
From Mr. F. Walsh, Journals and aeronautical papers.
From Mr. W. G. Gould, Journals for 1930.
From Messrs. A. V. Roe, the Handbook of the new Avro Training Machine.
From Mr. V. S. Gaunt, 53 lantern slides of aircraft.

The Council are very anxious to increase their slide collection and their collection of photographs. Many gifts of slides and photographs have been received from members and the two collections are now beginning to be of very definite value, but there are many gaps which it is hoped that members will fill by presentations.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on March 17th, 1931:—

Fellow (from Associate Fellow).—Arthur Gouge.

Associate Fellows.—Arthur James Lorne (from Associate Member), John Alfred Medhurst, Frank Nixon.

Associate (from Student).—Frank Lionel Tollow.

Students.—George Norman Beckmann, Bosco Davitcho, Herbert Marcus Kemp, Roy Dennis Stoner.

Subscriptions of Members

Members are reminded that all annual subscriptions became due on January 1st. The rates are:—

	Home.			Abroad.		
	£	s.	d.	£	s.	d.
Fellow	4	4	0	3	3	0
Member	4	4	0	3	3	0
Associate Fellow	3	3	0	2	2	0
Associate Member	3	3	0	2	2	0
Associate	*2	2	0	*2	2	0
Student	1	1	0	1	1	0
Companion	2	2	0	2	2	0
Founder Member	2	2	0	2	2	0

* £1 1s. 0d. without Journal.

The attention of all members is drawn to Rule 70, which reads as follows:—

"Any Fellow, Member, Associate Fellow, Associate Member, Associate, Student, Companion, or Founder Member, whose subscription shall not have been paid before the first day of April, shall be in arrears of subscription and shall not be entitled to attend or vote at any meeting or to receive any publications to which he would otherwise be entitled."

Under this Rule no Journals are sent to members whose subscriptions are still outstanding on April 1st. The Council hope that every member will realise fully the importance of paying his subscription as promptly as possible, as it is not practicable to supply back numbers of the Journal to those whose subscriptions are outstanding for any length of time.

Correction

In the correspondence from F./O. F. Whittle, which appeared in the March JOURNAL, Figs. 1 and 3 should be transposed.

Forthcoming Events

April 13th.—Coventry Branch. "Helicopters," by Captain R. N. Liptrot, O.B.E., B.A., A.F.R.Ae.S., M.I.Ae.E.

April 16th.—Lecture before the Society, by Dr. A. H. Davis, on "Aircraft Noise," 6.30 p.m., at the Royal Society of Arts.

April 28th.—Students' Section. Lecture on Airships, by Mr. E. Wieser, B.Sc., D.I.C.

April 30th.—Lecture before the Society, by Dr. Manfred Curry, on "Aerodynamics of Sails," 6.30 p.m., at the Royal Society of Arts.

J. LAURENCE PRITCHARD, *Secretary.*

OBITUARY

CHARLES RUMNEY SAMSON, *Associate Fellow*
1883—1931

The Council deeply regret to record the death of Air-Commodore Charles Rumney Samson, C.M.G., D.S.O., A.F.C., *Associate Fellow*, who died suddenly on February 5th, 1931.

Charles Rumney Samson was born at Cheetham, Lancashire, and entered the Royal Navy in 1898, serving in the Somaliland Operations of 1903-4 and the Operations in the Persian Gulf in 1909-10. In 1911, when Mr. (now Sir Francis) Frank McClean offered to provide facilities to naval officers who wished to fly, Samson was one of the four officers chosen by the Admiralty to take a course at Eastchurch.

From the beginning Samson showed the keenness in the air he had shown at sea. He took the Royal Aero Club's certificate in April, 1911, and in the October of that year was successful in persuading the Admiralty to form a flying school at Eastchurch. Shortly afterwards he made a flight from the deck of H.M.S. *Africa*, the first of its kind in Europe. In those early days Samson had the vision that aircraft would be the dominating weapon of war of the future.

In 1911-12 he was a member of the Technical Sub-Committee which prepared a scheme for the formation of the Royal Flying Corps, and early in 1912 he took over the new Naval Flying School at Eastchurch, where he carried out some of the earliest experiments with bomb dropping and wireless. He was in command of the Naval Air Unit which flew to Ostend on August 10th, 1914, and under his command the flight carried out reconnaissance flights and made the first night-flying of the War. The story of the Eastchurch Squadron and its adventures, before it was withdrawn from Dunkirk in 1915, is told in Samson's book, " Flight and Fights." For his work with the squadron he was promoted to Commander by the Admiralty, received the D.S.O., the *Croix de Guerre* and was made a Chevalier of the Legion of Honour.

In March, 1915, Samson was placed in command of No. 3 wing and took part in the Dardanelles adventure. Following the end of the Gallipoli campaign, he took command of the converted Isle of Man packet boat, H.M. Aircraft Carrier *Ben-my-chree*, from April, 1916-June, 1917. The ship was destroyed by Turkish gunfire in the harbour of Castellorizo, and Samson was appointed to the command of the *Raven II*, and scoured the Indian Ocean with seaplanes in search of submarines. For his work he was awarded a bar to his D.S.O.

In November, 1917, Samson took over the command of the Naval Air Station at Great Yarmouth, and in October, 1918, that of the group at Felixstowe, and in January, 1919, he received the Air Force Cross for his experimental work in flying aircraft from lighters towed behind destroyers. A Wing Commander on the formation of the R.A.F., he was promoted a Group Captain in August, 1919, and Air Commodore in January, 1921. Immediately following the War he was Chief Staff Officer at Headquarters, Coastal Area, and in 1921 took over the command of the R.A.F. in the Mediterranean. In 1926 he commanded the service flight of Vickers Victorias which flew from Heliopolis to Aden and back, and in 1927 the service flight of Fairey III F.'s from Cairo to Cape Town and back. In the August of that year he was placed on the half-pay list, and in November, 1929, on the retired list.

With the retirement of Air Commodore Samson the Royal Air Force lost one of its most adventurous spirits. In the flying game from the very beginning he became a leader. No enterprise was so hazardous, no adventure so uncertain in its end, but Samson was in it as its leader. He was essentially a great leader in the older sense, but he was too impatient when it came to the organisation and administration which is necessary in the higher ranks of the fighting forces. But for that impatience Air Commodore C. R. Samson would have had open to him the highest rank in the Royal Air Force, for in many ways he was a genius and far-sighted, and had an energy, a will to conquer difficulties—as shown by his many improvisations before and during the War—which would have been of the utmost value.

To Charles Rumney Samson the Royal Air Force owes much, and not the least that he embodied that spirit of adventure without which the Royal Air Force cannot exist.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

MAY 1931

Annual General Meeting

The Annual General Meeting of the Society was held on March 30th, 1931, in the Library of the Society.

Present:—

Mr. C. R. Fairey, M.B.E., F.R.Ae.S., President, in the chair.

Council: Messrs. Barlow, Blackburn, Buchanan, Bulman, Kennedy, Lamplugh, Manning, Master of Sempill, Wimperis and Wingfield.

Ordinary Members: Miss L. Chitty, Messrs. R. E. H. Allen, G. N. Ashcroft, R. L. Carter, C. N. Colson, J. F. Cuss, H. Glaser, C. W. Lawson, G. Merton, F. A. Norton and B. M. Whitehead.

Captain J. Laurence Pritchard (Secretary), Miss Jarvis and Miss Todd.

The notice convening the meeting was read and the Minutes of the last General Meeting, having been published in the JOURNAL for December, 1930, were taken as read, and signed.

The President, in opening the meeting, reviewed the year's activities as detailed in the Annual Report of the Council. It had been a year of great progress in the matter of membership, lectures and papers read and published, in increased circulation of the JOURNAL, and added prestige not only at home but in every part of the world. Dealing with the Annual Balance Sheet, the President emphasised that, while an actual increase of income over expenditure was shown, this had only been made possible by grants which had generously been forthcoming, and that it was the aim of the Council, through the Endowment Fund, to make the Society self-supporting. He asked all members to keep the Endowment Fund constantly before them and to help in every possible way, either by contributing or by any suggestions or names of those who might be approached.

The President paid tribute to the Daniel Guggenheim Fund for the Promotion of Aeronautics, the Air Ministry, the Society of British Aircraft Constructors and the Society of Motor Manufacturers and Traders, for their generous help in enabling the Society to achieve all that it had achieved during the past few years.

The President concluded his speech by thanking the Council and officers and the various Committees for the very hard work they had put in during the year.

As announced in the April JOURNAL, no election to Council was necessary this year, there being the same number of candidates as there were vacancies. A full list of the Council for 1931-2 appeared in the April issue.

Mr. Wingfield proposed, and Mr. Manning seconded, that Messrs. Price, Waterhouse and Co. be re-appointed Auditors. The resolution was carried unanimously.

The following alteration to Rule 86 was considered:—

> "One half of the Council (excluding the President and the Immediate Past-President if a member of Council) shall retire annually. The members who shall retire shall be those longest in office, except as provided in Rule 92. Retiring members of Council who have served for two terms in succession (four years) shall not be eligible for re-election until the next annual election, when they will be eligible."

Major Kennedy moved that the resolution be deferred for at least five years as he considered it would not be in the best interests of the Society to take any step which would limit its power to draw upon the help and advice which could be given by members of the aeronautical community on the Society's Council. Major Kennedy pointed out that the number of useful people available was bound to be small for, at any rate, the next few years.

Dr. Merton suggested that the matter might be dealt with by the appointment of special people as Vice-Presidents, but it was pointed out that under the present rules this would not be practicable as all the Society's Vice-Presidents must be members of Council.

Mr. Wingfield pointed out that the main reason for submitting the resolution was to facilitate the carrying out of a decision previously arrived at by the Council—that awards should not be made to members of Council.

The amendment was then put to the meeting and defeated. The original resolution was then seconded by Flight Lieutenant Allen and carried.

Colonel the Master of Sempill (Immediate Past-President) proposed a cordial vote of thanks to Mr. Fairey for the tremendous amount of enthusiasm he was putting in as President of the Society, which he hoped he would be able to continue for many years.

Mr. Fairey, in responding, again laid stress on the importance of the Endowment Fund, which must not be confused with the scheme for a new building. What he wanted to see in the near future was a sound financial basis on which the Society could carry on and increase its normal activities and render itself independent of grants which had been so generously given hitherto, and without which the Society's present position could never have been achieved.

The meeting then closed.

Endowment Fund

Many members who are anxious to help the Endowment Fund, have asked the Secretary if it is possible to give them some idea of how much they should contribute. The answer is simple, as much as they can. Everyone, indeed, who has the welfare of the Society at heart, should come forward now to help. The times admittedly are difficult, but it is in difficult times that help is wanted, and a stream of small donations to the Endowment Fund is more useful now in many ways than a few large sums in the future. The Society must be always indebted to its members for its very existence. It is a fact which has been constantly reiterated in these notices, for it is one which has a tendency to be overlooked by the members themselves. It is a healthy sign when members themselves are continually raising questions which have got to be answered, for that shows they are definitely interested. And from the number of questions which come in every day for the Secretary to answer, there is no doubt of the interest which is being shown, no doubt that these notes are read very closely by the majority who receive the JOURNAL.

The Endowment Fund is increasing steadily every month, but the rate of that increase is not great enough. It is to be hoped that each member will consider carefully how he can help to accelerate the rate of increase.

Endowment Fund Appeal Acknowledgments

	£	s.	d.
Already acknowledged	549	10	0
Callender's Cable and Construction Co., Ltd.	10	10	0
The Surrey Gliding Club	1	1	0
A. G. Hazell, Esq.	3	3	0
The Technological Institute of Great Britain	5	5	0
Messrs. Gale and Polden, Ltd.	25	0	0
H. B. Irving, Esq., A.F.R.Ae.S.	1	1	0
	£595	10	0

The total of the Fund is £1,873 0s. 0d.

Wilbur Wright Memorial Lecture

With the concurrence of Mr. Orville Wright and Mr. Griffith Brewer (Trustees of the Wilbur Wright Memorial Lecture Fund), the Council have postponed the reading of the Wilbur Wright Memorial Lecture to Thursday, September 17th, 1931. The date chosen is in the week following the Schneider Trophy Race, which takes place on Saturday, September 12th, 1931, and has been chosen so that as many as possible of the distinguished visitors to this country may have an opportunity of meeting members of the Royal Aeronautical Society.

The lecture will be given by Mr. Glenn Martin, the well-known American pioneer and aircraft constructor, and the title of his lecture will be "The Development of Aircraft Manufacturing."

The lecture will be preceded by a Council dinner and afterwards there will be a reception and conversazione.

Council Meeting

A Meeting of Council was held on Tuesday, April 21st, 1931. Present: In the chair, Mr. C. R Fairey, President; Captain P. D. Acland, Major T. M. Barlow, Professor L. Bairstow (Vice-President), Mr. Robert Blackburn, Major J. S. Buchanan, Major G. P. Bulman, Mr. A. H. Hall, Captain F. T. Hill, Mr. J. E. Hodgson (Honorary Librarian), Major D. H. Kennedy (Honorary Treasurer), Captain A. G. Lamplugh, Mr. M. Langley, Mr. W. O. Manning, Colonel the Master of Sempill (Past-President), Lieut.-Colonel F. C. Shelmerdine, Mr. H. E. Wimperis (Vice-President), Mr. L. A. Wingfield (Honorary Solicitor), Mr. R. McKinnon Wood.

Among the business transacted was the appointment of Committees of Council for 1931-32; the Endowment Fund Appeal; Report of the Finance Committee; Report of the Grading Committee; the Wilbur Wright Memorial Fund Lecture.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on April 21st, 1931:—

Associate Fellows.—Kshetra Mohan Raha, Seymour Cunningham Redshaw (from Associate), Paul Hamar Stanley, Clarence Marshall Young.

Associate Members.—Henry Lawrence Christie (re-elected), Walter Croft Clayton.

Associates.—Arthur Haycroft Acford, William Henry Burn, John Talbot Dyment (from Student).

Students.—Robert Henry William Beer, Eric Joscelyn George, Robert Fuller George, Cyril Herbert Nundy, David Hay Surgeoner.

Companions.—Sydney Hansel (from Student), E. Colston Shepherd.

Committees

The following Committees of Council have been appointed for 1931-32:—

Grading Committee:

Captain F. S. Barnwell, Mr. R. A. Bruce, Major F. A. Bumpus, Mr. W. S. Farren, Lieut.-Colonel L. F. R. Fell, Mr. A. Gouge, Captain F. T. Hill, Mr. R. J. Mitchell, Mr. W. P. Savage, Prof. R. V. Southwell and Dr. H. C. Watts.

Finance Committee:

Captain P. D. Acland, Mr. E. C. Gordon England, Mr. C. R. Fairey, Captain F. T. Hill, Mr. J. E. Hodgson, Major D. H. Kennedy, Captain A. G. Lamplugh, Mr. W. P. Savage, Mr. F. R. Simms, Mr. A. N. D. Smith and Mr. L. A. Wingfield.

Building Sub-Committee:

Major D. H. Kennedy, Mr. F. R. Simms, Mr. L. A. Wingfield, Colonel the Master of Sempill.

Informal Discussions' Committee:

Major T. M. Barlow, Mr. M. L. Bramson, Major G. P. Bulman, Mr. F. A. Foord, Mr. D. R. Pye and Mr. C. C. Walker.

Lectures Committee:

Mr.. R. S. Capon, Captain F. Entwistle, Mr. H. Glauert, Major F. M. Green, Mr. S. Scott Hall, Captain G. T. R. Hill, Mr. H. B. Irving, Mr. M. Langley, Mr. R. K. Pierson, Mr. D. R. Pye and Mr. C. C. Walker.

Joint Standing Committee with the Society of British Aircraft Constructors and the Royal Aero Club:

Colonel the Master of Sempill, Air Vice-Marshal Sir Vyell Vyvyan and Captain A. G. Lamplugh.

Educations and Examinations Committee:

Major T. M. Barlow, Prof. L. Bairstow, Mr. W. E. Dumbrill, Mr. A. T. E. Eadon, Captain F. T. Hill, Prof. Melvill Jones, Mr. W. M. Page, Dr. N. A. V. Piercy, Mr. H. T. Tizard, Captain G. W. Wilkinson and Mr. L. A. Wingfield.

(Further names are being added.)

Representatives on Other Bodies.

British Engineering Standards Association Aircraft Committee: Major R. H. Mayo and Dr. H. C. Watts.

Advisory Council of the Science Museum: Colonel the Master of Sempill.

National Central Library: Mr. J. E. Hodgson.

Students' Section: Mr. G. W. Mullet (Honorary Secretary).

Association of Special Libraries and Information Bureau: Mr. J. E. Hodgson (Hon. Librarian).

Advisory Committee on Aeronautical Education of the Imperial College: Mr. C. R. Fairey.

B.E.S.A. Committee on Symbols and Abbreviations Used in Engineering: Major A. R. Low.

Lloyds Aviation Committee: Lieut.-Col. J. T. C. Moore-Brabazon.

British Corporation Register of Shipping and Aircraft, Aviation Committee: Colonel the Master of Sempill.

Segrave Memorial Fund Committees: Mr. C. R. Fairey.

British Gliding Association: Council: Colonel the Master of Sempill. Technical Committee: Capt. J. L. Pritchard.

Handbook of Aeronautics

The attention of all members of the Society is called to the "Handbook of Aeronautics," which has been published with the approval of the Council, and a review of which appears in this issue.

The "Handbook of Aeronautics" is an attempt to collect together in an easily usable form the immense amount of scattered information now to be found in aeronautics, information of everyday use to the designer and constructor of aircraft, and the aeronautical engineer.

Copies of the handbook may be obtained direct from the offices of the Society, price 25/- net, or 25/9 post free.

Subscriptions of Members

Members are reminded that all annual subscriptions became due on January 1st. The rates are:—

	Home.			Abroad.		
	£	s.	d.	£	s.	d.
Fellow	4	4	0	3	3	0
Member	4	4	0	3	3	0
Associate Fellow	3	3	0	2	2	0
Associate Member	3	3	0	2	2	0
Associate	*2	2	0	*2	2	0
Student	1	1	0	1	1	0
Companion	2	2	0	2	2	0
Founder Member	2	2	0	2	2	0

* £1 1s. 0d. without Journal.

The attention of all members is drawn to Rule 70, which reads as follows:—

> "Any Fellow, Member, Associate Fellow, Associate Member, Associate, Student, Companion, or Founder Member, whose subscription shall not have been paid before the first day of April, shall be in arrears of subscription and shall not be entitled to attend or vote at any meeting or to receive any publications to which he would otherwise be entitled."

Under this Rule no Journals are sent to members whose subscriptions are still outstanding on April 1st. The Council hope that every member will realise fully the importance of paying his subscription as promptly as possible, as it is not practicable to supply back numbers of the Journal to those whose subscriptions are outstanding for any length of time.

Forthcoming Events

May 4th.—Oxford Branch. "Early Flying Experiences." Lecture by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.I.Ae.E., Vice-President of the Society.

May 14th.—Lecture before the Society at the Royal Society of Arts, 6.30 p.m. "The Metal-Clad Airship." Mr. Carl Fritsche.

J. LAURENCE PRITCHARD, *Secretary.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

JUNE 1931

President, 1931-32

Mr. C. R. Fairey, M.B.E., F.R.Ae.S., who was elected President of the Society in June, 1930, for the period October, 1930-September, 1931, was unanimously elected for a second period of office (October, 1931-September, 1932) at the Council Meeting held on May 19th, 1931.

Mr. Fairey's first year of office has not yet been completed, but his first lecture session as President has. The lectures this year under his presidency have been extremely well attended. Following a number of these lectures Mr. Fairey has given a dinner to the lecturer to enable the latter to meet the leaders in this country in his own particular sphere of aeronautics. Mr. Fairey has made a special appeal on behalf of the Endowment Fund, and already, thanks to his own personal efforts, the Fund has been increased by over £500.

Vice-Presidents

At the Meeting of the Council held on May 19th, 1931, the following were re-elected Vice-Presidents of the Society for 1931-32 :—

Professor L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.
Lt.-Col. J. T. C. Moore-Brabazon, M.C., F.R.Ae.S.
Mr. H. E. Wimperis, C.B.E., M.A., F.R.Ae.S.

At the same meeting Mr. Griffith Brewer, F.R.Ae.S., was elected a Vice-President in place of Air-Vice-Marshal Sir Vyell Vyvyan, who resigned from the Council in March.

Endowment Fund

It is difficult every month to make a fresh and reasoned appeal on behalf of the Endowment Fund, for arguments may be presented *ad nauseam* until the very heading of a paragraph by the words " Endowment Fund " is sufficient to make the reader skip that paragraph. But a short paragraph may hit the mark, and a short appeal may focus attention.

Have you *personally* considered the Endowment Fund and its ultimate benefit to you?

Council Meeting

A Meeting of Council was held on Tuesday, May 19th, 1931, in the offices of the Society.

Present :—Mr. H. E. Wimperis (Vice-President) in the Chair; Major T. M. Barlow; Mr. M. L. Bramson; Mr. Griffith Brewer; Major G. P. Bulman; Mr. A. H. Hall; Capt. F. T. Hill; Major D. H. Kennedy (Hon. Treasurer); Mr. W. O. Manning and Mr. L. A. Wingfield (Hon. Solicitor).

Among the business considered by the Council was: The appointment of additional members to the Education and Examinations Committee; the date of the Wilbur Wright Memorial Lecture; the report of the Finance Committee; the report of the Grading Committee; the appointment of a delegate to the Centenary

Meeting of the British Association; the election of the President and Vice-Presidents for 1931-32.

Elections

The following recommendations of the Grading Committee were approved by the Council at the meeting on May 19th, 1931 :—

Associate Fellows.—Adirio Orfelio Jesson, Joseph Kampe de Feriet.
Associate Member.—Robert Ross.
Associates.—Stanley Alfred Seager, Harold Stringer.
Students.—Eugene James Earle, Ernest Parr Hessey, Robert Fairfax Lucy, Henry Charles Stocks, Theodore Michael Walker.

British Association

Mr. H. E. Wimperis, C.B.E., F.R.Ae.S., Vice-President, has been appointed the Society's delegate for the Centenary Meeting of the British Association in September, 1931.

Housing Scheme

Major D. H. Kennedy, O.B.E., F.R.Ae.S., has been appointed the Society's delegate to a meeting of various engineering and technical societies, to discuss a general engineering building.

Wilbur Wright Memorial Lecture

The date of the Wilbur Wright Memorial lecture has been fixed for Wednesday, September 16th, 1931, instead of Thursday, September 17th, 1931, as announced in last month's JOURNAL. The lecture will be delivered in the Aeronautical Section of the South Kensington Museum, by kind permission of the Director, Colonel Sir Henry Lyons, and will be followed by a Conversazione.

Education and Examinations Committee

The following additional members have been appointed to the Education and Examinations Committee.

Mr. D. R. Pye, M.A., F.R.Ae.S.
Mr. R. S. Capon, O.B.E., B.A., F.R.Ae.S.
Mr. R. K. Pierson, M.B.E., B.Sc., Assoc.M.Inst.C.E., F.R.Ae.S.
Mr. W. P. Savage, A.F.R.Ae.S.

Handbook of Aeronautics

The Handbook of Aeronautics, published with the approval of the Council, collects together in an easily usable form the immense amount of scattered information now to be found in aeronautics, information of every-day use to the designer and constructor of aircraft, and the aeronautical engineer.

Copies of the Handbook may be obtained direct from the offices of the Society, price 25/- net or 25/9 post free.

Royal Air Force Display

The Royal Air Force Display will be on Saturday, June 27th at Hendon. The library will be closed that day as from 12.30 p.m.

Ottawa Branch

An Ottawa Branch of the Royal Aeronautical Society, which also forms the Ottawa Aeronautic Section of the Engineering Institute of Canada, has been formed. Its Chairman is Professor Parkin, and its Secretary Squadron Leader A. Ferrier. The branch has a membership of 150 and a number of lectures have been read before it, which will shortly be published and circulated to members of the Society.

J. LAURENCE PRITCHARD, *Secretary.*

THE
ROYAL AERONAUTICAL SOCIETY
With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

JULY 1931

Council Meeting

A Meeting of Council was held on Wednesday, June 24th, 1931, in the Offices of the Society.

Present: Colonel the Master of Sempill (Past President), in the chair, Captain P. D. Acland, Major G. P. Bulman, Mr. A. H. Hall, Captain F. T. Hill, Captain A. G. Lamplugh, Mr. W. O. Manning, Mr. A. F. Sidgreaves, Mr. L. A. Wingfield (Hon. Solicitor), and Mr. R. McKinnon Wood.

Among the business considered by the Council was: Aeronautical Trusts, Ltd.; the Report of the Finance Committee; the Report of the Grading Committee; lectures before Public Schools; the appointment of a representative on the Advisory Committee for Aeronautics at University College, Hull.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on June 22nd, 1931:—

Associate Fellows.—William George Bird, Carl Berges Fritsche, John Megarry Furnival, Beverley Strahan Shenstone (from Student).

Associate Member.—Manohar Gopal Pradhan.

Students.—James Van Stockum Brotherhood, Neville Gainford Dixon, Jack Eliot Duckham, Arthur James Horace Hart, Tulsi Dass Kumar, Harry Ledger, John Nicholls, Cyril Arundel Penberthy, Peter Reginald Poole, William Lawrence Thomas.

Companion.—William Pasifull Lascelles Bowen (from Student).

Air Vice-Marshal Sir Sefton Brancker

The Secretary has been asked to edit the memoirs of the late Air Vice-Marshal Sir Sefton Brancker, who was for many years a member of Council and at one time President of the Society. It would be of great assistance to him if any member who has any story to tell of the late President, or any letters or documents, or photographs of interest, would lend them for the purposes of the biography. All documents, photographs and letters would be carefully copied and returned to their senders.

Royal Air Force—Aircraft Apprentices

Four hundred aircraft apprentices, between the ages of 15 and 17, are required by the Royal Air Force for entry into the Schools of Technical Training at Halton, Bucks., and at Cranwell, near Sleaford, Lincs. They will be enlisted as the result of an Open Competition and of a Limited Competition, and these competitions will be held in the near future by the Civil Service Commissioners and

the Air Ministry respectively. Boys in possession of an approved first school certificate may be admitted without other educational examinations. Successful candidates will be required to complete a period of 12 years' regular Air Force service from the age of 18, in addition to the training period. At the age of 30 they may return to civil life, or, upon attaining N.C.O. rank, and subject to Service requirements, may be permitted to re-engage to complete time for pension.

Full information regarding the dates of the respective examinations, the methods of entry and the aircraft apprentice scheme generally can be obtained upon application to the Secretary, Air Ministry (Aircraft Apprentices' Dept.), Gwydyr House, Whitehall, London, S.W.1. The sons of officers, warrant officers, and senior N.C.O.s of the three services will receive special consideration.

Publications

With this issue of the Journal each member should receive a copy of the Publications of the Society. This also contains a list of the chief papers and articles which have been published in the Journal since 1917.

Acknowledgments

The Council gratefully acknowledge the donation of Journals from Captain H. R. Gillman. The Journals cover a period from 1912 to 1931 and have proved invaluable for filling up gaps in the Society's file of Journals.

Journals

A number of wrappers for the May Journal addressed to certain Associate Fellows were lost in the post. Will those Associate Fellows who have not yet received the May Journal, and whose subscriptions have been paid, please notify the Editor, so that their Journals can be sent to them?

Handbook of Aeronautics

The Handbook of Aeronautics, published with the approval of the Council, collects together in an easily usable form the immense amount of scattered information now to be found in aeronautics, information of every-day use to the designer and constructor of aircraft, and the aeronautical engineer.

Copies of the Handbook may be obtained direct from the offices of the Society, price 25/- net or 25/9 post free.

J. LAURENCE PRITCHARD, *Secretary.*

THE
ROYAL AERONAUTICAL SOCIETY

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MONTHLY NOTICES

AUGUST, 1931

Wilbur Wright Memorial Lecture

The Wilbur Wright Memorial Lecture will be delivered by Mr. Glenn Martin on Wednesday, September 16th, 1931, at 9.15 p.m. in the Science Museum, South Kensington. The title of the lecture is "The Development of Aircraft Manufacturing."

On the evening of the delivery of the lecture the Society will hold a Conversazione in the Aeronautical Section of the Science Museum, by kind permission of Colonel Sir Henry Lyons. This date has been selected because at that time most of the foreign notabilities in the aeronautical world will be in England for the Schneider Trophy Contest and will be specially invited to attend the conversazione, at which most of the leaders in British aviation will also be present.

The programme for the evening is as follows:—

8.30— 9 p.m. Reception by the President, Mr. C. R. Fairey, M.B.E., F.R.Ae.S., and the Council.

9.15—10 p.m. Delivery of the Wilbur Wright Memorial Lecture by Mr. Glenn Martin.

10 p.m.—midnight. Conversazione.

By kind permission of the Air Council the Band of H.M. Royal Air Force will play from 8.30 to 9 p.m. and from 10 p.m. to 11.45 p.m.

A distinguished company will be present and it is hoped that there will be a large attendance of members and their guests. Admission will be by ticket only, and applications may be received from non-members. Ladies are specially invited to be present. Evening dress with orders and decorations will be worn.

Tickets (including Buffet) are 5/- each, and early application is advised as it may not be possible to accommodate late comers.

Lecture Programme, 67th Session

The Lecture Programme of the 67th Session of the Royal Aeronautical Society has been provisionally arranged as follows:—

Wednesday, September 16th.—The Wilbur Wright Memorial Lecture, Mr. Glenn Martin.

Thursday, October 8th.—Professor Piccard on his experiences in his famous balloon ascent.

Thursday, October 15th.—Mr. H. Sutton, M.Sc., A.F.R.Ae.S., "The Protection of Metals in Aircraft Construction."

Thursday, October 29th.—Captain A. F. Lamplugh, F.R.Ae.S., M.I.Ae.E., "Accidents in Civil Aviation."

Thursday, November 5th.—Mr. H. B. Irving, B.Sc., A.F.R.Ae.S., and Mr. A. V. Stephens, "Safety in Spinning."

Thursday, November 19th.—Mr. H. Constant, "Aircraft Vibration."

Thursday, December 3rd.—Mr. S. Scott Hall, M.Sc., D.I.C., A.F.R.Ae.S., "Wheel Brakes and Undercarriages."

Thursday, December 10th.—Mr. W. S. Farren, M.B.E., F.R.Ae.S., M.I.Ae.E., "Air Flow—Demonstrations on the Screen by means of Smoke."

Thursday, December 17th.—Dr. G. V. Lachmann, A.F.R.Ae.S., "Control Beyond the Stall."

1932.

Thursday, January 14th.—Mr. E. Ower, F.R.Ae.S., "Interference."

Thursday, January 28th.—Mr. A. E. Woodward-Nutt, B.A., A.F.R.Ae.S., and Flight Lieutenant A. F. C. Scroggs, "The Effect of Height on Range."

Thursday, March 10th.—Mr. E. F. Relf, F.R.Ae.S., "Results with the new Wind Tunnel at the N.P.L."

A number of other lectures are being arranged, and all particulars will be published as soon as dates are fixed

Council Meeting

No meeting of Council was held in July. The next meeting of Council will be early in September.

Elections

The following are additional elections to those of June 24th :—

Associate Fellow.—Eric William Edwards.

Associate Member.—William George Bruce Callingham.

Acknowledgments

The Council wish to acknowledge the gift of one of the group photographs of members of the Society from Captain R. O. King; from Dr. Ing. Ph. Theodorides, Associate Fellow, Papers on Aeronautics 1927-30, published in Athens, and a paper on the Scientific and Technical Bases and Progress of Aeronautics, published in Athens; from Mr. G. Tilghman Richards a collection of private stress calculations of the War Period, a collection of great historical interest; and from Mr. G. F. Rayner the gift of a large number of early copies of the JOURNAL and "Aeronautics."

Correction

In the paper on *Least Work* published in the July Journal, p. 654, line 5, the sign between U_3 and U_1 should read "not equal to," and p. 657, line 7 from bottom, for direct cosines read "direction cosines."

Air Vice-Marshal Sir Sefton Brancker

The Secretary has been asked to edit the memoirs of the late Air Vice-Marshal Sir Sefton Brancker, who was for many years a member of Council and at one time President of the Society. It would be of great assistance to him if any member who has any story to tell of the late President, or any letters or documents, or photographs of interest, would lend them for the purposes of the biography. All documents, photographs and letters would be carefully copied and returned to their senders.

Handbook of Aeronautics

The Handbook of Aeronautics, published with the approval of the Council, collects together in an easily usable form the immense amount of scattered information now to be found in aeronautics, information of every-day use to the designer and constructor of aircraft, and the aeronautical engineer.

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J. LAURENCE PRITCHARD, *Secretary*.

OBITUARY

BEAUMARIS WOODWARD

It is with very great regret that the Council have to record the death of Beaumaris Woodward, who was, for so many years, Honorary Solicitor to the Society. Mr. Woodward was elected a member of the Society at the Council meeting held on February 20th, 1911, and almost immediately it was recognised that in its new member the Society had someone of great energy and foresight. In October, 1911, Mr. Woodward was elected Honorary Solicitor to the Society and began immediately to draft up the Articles of Association for Aerial Science, Ltd. It was due to Mr. Woodward's far-sighted policy at that time that the Society was placed on a firm basis, and the Council feel that every member owes to him a deep debt of gratitude for work undertaken at a time when there appeared no real incentive for it to be undertaken. For nearly twenty years the advice of Mr. Woodward on all legal matters was very freely placed at the disposal of the Council, and during those years Mr. Woodward gave up much valuable time to straightening out, voluntarily, legal matters that came up for consideration.

Some two years ago Mr. Woodward was stricken with an illness which prevented him from taking an active part in the meetings of the Council, but up to the day of his death he took a keen interest in the Society's activities, and on many occasions expressed his deep regret that he was unable to attend the Society's functions. The Society, indeed, was his hobby and one which he rode with an enthusiasm tempered by a solid sense of values which commanded a respect for any views he put forward.

Beaumaris Woodward was born at Plumpton Rectory, Sussex, July 11th, 1855, the son of the Rev. William Woodward, whose ancestors had held the living in unbroken succession from the year 1600. After leaving Felstead he was articled to his brother-in-law to be trained as a solicitor, and on completing his articles spent some time in Canada and New York. In 1890 he began practice as a solicitor in the City of London.

Although in his 60th year at the outbreak of War he at once joined the Old Boys' Corps. The heavy physical work involved proved too much for him and he resumed his work as a solicitor, taking up a position in an office so that younger men could be released. In September, 1928, his health failed, and from that time until his death on June 14th, 1931, he was a complete invalid. Mr. Woodward leaves a widow and one daughter, to whom the Council wish to express their condolence on the death of so well known and respected a member of the Society.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

SEPTEMBER 1931

Conversazione and Wilbur Wright Memorial Lecture

The Wilbur Wright Memorial Lecture will be delivered by Mr. Glenn Martin on Wednesday, September 16th, 1931, at 9.15 p.m. in the Science Museum, South Kensington. The title of the lecture is "The Development of Aircraft Manufacture."

On the evening of the delivery of the lecture the Society will hold a Conversazione in the Aeronautical Section of the Science Museum, by kind permission of Colonel Sir Henry Lyons. This date has been selected because at that time most of the foreign notabilities in the aeronautical world will be in England for the Schneider Trophy Contest and will be specially invited to attend the conversazione, at which most of the leaders in British aviation will also be present.

The programme for the evening is as follows:—

8.30— 9 p.m. Reception by the President, Mr. C. R. Fairey, M.B.E., F.R.Ae.S., and the Council.

9.15—10 p.m. Delivery of the Wilbur Wright Memorial Lecture by Mr. Glenn Martin.

10 p.m.—midnight. Conversazione.

By kind permission of the Air Council the Band of H.M. Royal Air Force will play from 8.30 to 9 p.m. and from 10 p.m. to 11.45 p.m.

A distinguished company will be present and it is hoped that there will be a large attendance of members and their guests. Admission will be by ticket only, and applications may be received from non-members. Ladies are specially invited to be present. Evening dress with orders and decorations will be worn.

Tickets (including Buffet) are 5/- each, and early application is advised as it may not be possible to accommodate late comers.

Air Vice-Marshal Sir Sefton Brancker

The Secretary has been asked to edit the memoirs of the late Air Vice-Marshal Sir Sefton Brancker, who was for many years a member of Council and at one time President of the Society. It would be of great assistance to him if any member who has any story to tell of the late President, or any letters or documents, or photographs of interest, would lend them for the purposes of the biography. All documents, photographs and letters would be carefully copied and returned to their senders.

Library

A number of books have been borrowed from the Library by members who have not filled in the necessary requisition form with the result these books cannot be traced. As they are all books which are in constant demand the Council would be glad if any member who has any book at present will return it to the Library by September 15th.

The books in the Library are chiefly for reference purposes and though the comparatively long period of three weeks is allowed for the borrowing of a book, the increasing failure of members to return books within that period has caused the Council to consider seriously whether the present period should be curtailed. The books in the Library are not intended to replace those which would ordinarily have to be bought by the individual concerned in the natural course of his studies or his work.

The Council have arranged that the annual Library stock-taking shall take place on Tuesday, September 15th, and for that purpose request that all those who are now in possession of books borrowed from the Library will return them on or before that date.

Corrections

In the paper by Mr. H. C. H. Townend the following corrections should be made:—

Footnote, p. 711, should read in full " National Physical Laboratory, Aerodynamics Department. Reprinted from R. & M. 1394 by kind permission of the Aeronautical Research Committee."

p. 713, line 8, for slot read slat; line 27, for closed read close.

p. 714, line 30, for 11½in. read 10½in.

The title under Fig. 3 should read " Mean velocity of slot air resolved normal to arc $x=0.02''$ " shown —[·]—

Fig. 12, Table 5 (*a*), etc., should read Table II (*a*), etc.

Forthcoming Event

Wednesday, September 16th.—Wilbur Wright Memorial Lecture and Conversazione in the Science Museum, South Kensington, 8.30 p.m.—12 p.m.

J. Laurence Pritchard, *Secretary*.

OBITUARY

The Council greatly regret to have to record the deaths of Mr. Edmond F. B. Bourne, a Companion of the Society since 1918, who died at Parkstone, Dorset, on June 19th, at the age of 66; of Professor Archibald Barr, Fellow of the Society since 1919, who died on August 5th in his 76th year; of William Lloyd Shiers, Associate Member, who died on August 4th in Johannesburg, as the result of an accident, at the age of 27; and of Major J. C. B. Firth, Companion, who died on August 23rd, at Blyth, Nottinghamshire, at the early age of 37.

Professor Barr was the Emeritus Professor of Civil Engineering and Mechanics at Glasgow University and took a lively interest in aviation, becoming the first President of the Scottish Branch of the Royal Aeronautical Society. Mr. Shiers was a very keen member, a member of the Johannesburg Light Plane Club, and kept in close touch with the Society and was constantly doing all he could to draw the attention of potential members in South Africa to the Society. His death is a great loss to aviation.

The Council wish to express their sincere condolences to the relatives of these members, all of whom showed an interest in aviation and encouraged others to do so to such an extent that their deaths will be a very great loss.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

OCTOBER 1931

The Engineering Journal

With this issue of the JOURNAL there accompanies it the first Aeronautical Section reprint of the *Engineering Journal*. This reprint follows an agreement between the Engineering Institute of Canada and the Royal Aeronautical Society. The Aeronautical Section reprint contains papers by Flight Lieut. J. R. Cairns, R.C.A.F., on "Aerial Cameras and Photography," read before the Ottawa Branch of the Society; by J. J. Green, A.R.C.Sc., Ph.D., on "Some Problems Connected with Fluid Motion," read before the Ottawa Branch; and by Lieut.-Colonel W. Arthur Steel, M.C., A.M.E.I.C., on "Communication on Civil Airways in Canada," read before the Montreal Branch.

These aeronautical reprints will be issued free with the JOURNAL as they appear.

School Lectures

The Council have made arrangements for lectures to be delivered before certain Public Schools. A series of 44 slides has been prepared together with full notes on them, so that the lecturer has, in effect, his lecture ready prepared and has little to do but deliver it.

A number of members of the Society have signified their willingness to deliver a lecture to one of the Public Schools and the Council will be glad to hear from any member who will help in this direction. The Council feel it is of great importance that the opportunity of rousing interest in the air among those who are bound to have a great influence during the coming years should be seized upon.

Council Meeting

A meeting of Council was held in the offices of the Society on Tuesday, September 8th, 1931.

Present:—Lieut.-Colonel J. T. C. Moore-Brabazon, Vice-President, in the chair; Major T. M. Barlow, Major G. P. Bulman, Mr. A. H. Hall, Captain F. T. Hill, Captain A. G. Lamplugh, Mr. M. Langley, Mr. W. O. Manning, Lieut.-Colonel F. C. Shelmerdine.

Among the business considered was the following:—Lectures before the Public Schools; the Lecture Programme of the Society; the Report of the Finance Committee; the Report of the Grading Committee; and the Report of the Awards and Medals Committee.

Elections

At a Council meeting held on September 8th, 1931, the following were elected:—

Fellow.—Ralph Hazlett Upson.

Associate Fellows.—Inglis Joseph Gerard, Doris Mona Hirst (from Companion), Henry Nigel St. Valery Norman (from Companion), Neill Charles Ogilvie-Forbes.

Associate Members.—Frederick Steadman Farrow, Arthur Steele Suddes.

Associates.—William Alexander Campbell, George Brereton Sadleir Falkiner (Australian Branch), Roderick George Morrison, Alan Charles Moyle (Australian Branch), Thomas James William Samuel Pearce, Willows Septimus Shaw, Ethelbert Victor Wraight (from Student).

Students.—Alfred Brain, Leslie Victor Clark, Thomas Alexander Couper (Australian Branch), Richard Frederick Fairbairn, Geoffrey Uffindell Hayns, Jack Kenneth Woolgar Wheatley.

Companions.—Harold M. Probyn (Squadron Leader, R.A.F.), Laurence Chase Sharman (Commander, R.N.), Charles Amherst Villiers.

Lecture Programme

The following is a list of lectures as at present arranged:—

1931.

Oct. 15th.—Mr. H. Sutton, M.Sc., A.F.R.Ae.S., "The Protection of Materials."

Oct. 29th.—Capt. A. G. Lamplugh, F.R.Ae.S., M.I.Ae.E., "Accidents in Civil Aviation."

Nov. 5th.—Mr. H. B. Irving, B.Sc., A.F.R.Ae.S., and Mr. A. V. Stephens, "Safety in Spinning."

Nov. 19th.—Mr. H. Constant, "Aircraft Vibration."

Dec. 3rd.—Mr. S. Scott-Hall, M.Sc., A.F.R.Ae.S., "Wheel Brakes and Undercarriages."

Dec. 10th.—Mr. W. S. Farren, M.B.E., F.R.Ae.S., M.I.Ae.E., "Airflow." (Demonstrations on the screen by means of smoke.)

Dec. 17th.—Dr. G. V. Lachmann, A.F.R.Ae.S., "Control Beyond the Stall."

1932.

Jan. 14th.—Mr. E. Owef, F.R.Ae.S., "Interference."

Jan. 28th.—Mr. A. E. Woodward-Nutt, B.A., A.F.R.Ae.S., and Flight Lieut. A. F. Scroggs, R.A.F., "The Effect of Height on Range."

Feb. 11th.—Mr. I. J. Gerard, M.Sc., A.F.R.Ae.S., "Mechanical Tests of Aircraft Components."

Feb. 25th.—Mr. P. Salmon, "Catapults."

March 1st (Tuesday).—Joint Meeting with the Institution of Automobile Engineers. Lecture by Mr. C. B. Dicksee on "Diesel Engines for Road Transport" (7.30 p.m.).

March 10th.—Mr. E. F. Relf, F.R.Ae.S., "Results with the New Wind Tunnel at the National Physical Laboratory."

April 14th.—Mr. W. L. Taylor, "Aero Engine Accessories."

All meetings will be held at 6.30 p.m. at the Royal Society of Arts, 18, John Street, Adelphi, W.C.2. With the exception of March 1st all the meetings are on Thursdays.

Medals and Awards

The following awards were made at the Council Meeting held on Tuesday, September 8th, 1931. Full particulars of the awards are given in the report, in this issue of the JOURNAL, of the Conversazione held on September 16th:—

Simms Gold Medal to Dr. A. H. Davis.

Taylor Gold Medal to Squadron Leader W. R. D. Acland.

Silver Medal to Mr. H. C. H. Townend.

Busk Memorial Prize to Mr. A. Gouge.

Pilcher Memorial Prize to Mr. S. G. Hooker.

R.38 Memorial Prize divided between Professor Southwell and Miss Chitty, and Mr. W. G. Bird.

Acknowledgment

The Council wish gratefully to acknowledge the gift to the library of a number of interesting old German books from Messrs. Trost Brothers, Ltd.

Advance Proofs

Advance proofs of lectures for the Session may be obtained on a prepayment of 8/-, post free. Single copies for any particular lecture are sixpence, or 7d. post free, from the offices of the Society.

Liberty Engine

A member is inquiring if any other member has a copy of A.P. 949 (Liberty Engine) which he would like to sell. If any member has, will he please communicate with the Secretary?

Group Photograph

A member has a group photograph, with key, of members of the Society which he would like to dispose of. Will any member wishing for a copy write to the Secretary?

Forthcoming Events

Thursday, October 1st.—Lecture before the Gloucester and Cheltenham Branch by Major T. M. Barlow, M.Sc., F.R.Ae.S., on "Recent Developments in Aircraft Engineering."

Thursday, October 8th.—Lecture before the Gloucester and Cheltenham Branch by Dr. L. Aitchison.

Friday, October 9th.—Lecture before the Foreman's Mutual Benefit Society by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Ten Years' Progress in Aviation with a Look into the Future," at the Charing Cross Hotel.

Saturday, October 10th.—Lecture before Ipswich School by Mr. W. O. Manning, F.R.Ae.S.

Thursday, October 15th.—Lecture, "The Protection of Materials," by Mr. H. Sutton, M.Sc., A.F.R.Ae.S., in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Tuesday, October 20th.—Lecture before the Bristol Branch by Mr. E. C. Gordon England, A.F.R.Ae.S., on "Soaring Flight; its Function in Aviation."

Thursday, October 22nd.—Lecture before the Gloucester and Cheltenham Branch by a representative of the Mond Nickel Co. on "Nickel and its Alloys."

Friday, October 23rd.—Lecture before Merchant Taylors' School by Mr. C. R. Fairey, M.B.E., F.R.Ae.S., President of the Society.

Thursday, October 29th.—Lecture, "Accidents in Civil Aviation," by Captain A. G. Lamplugh, F.R.Ae.S., M.I.Ae.E., in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Friday, October 30th.—Lecture before Eton College by Colonel the Master of Sempill, A.F.C., F.R.Ae.S., Immediate Past-President of the Society.

J. Laurence Pritchard, *Secretary*.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

NOVEMBER 1931

Members of Parliament

The following members of the Society were returned to Parliament in the recent elections:—

Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., Vice-President.
Mr. A. E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. O. E. Simmonds, F.R.Ae.S., M.I.Ae.E., M.A.

Council Meeting

A Meeting of Council was held in the offices of the Society on Tuesday, October 13th, 1931.

Present:—Mr. C. R. Fairey, M.B.E., F.R.Ae.S., in the chair. Captain P. D. Acland, Professor L. Bairstow, Major T. M. Barlow, Mr. M. L. Bramson, Mr. Griffith Brewer, Major G. P. Bulman, Mr. A. H. Hall, Captain F. T. Hill, Mr. J. C. Hodgson (Hon. Librarian), Major D. H. Kennedy (Hon. Treasurer), Mr. M. Langley, Mr. W. O. Manning, Colonel the Master of Sempill (Past-President), Mr. F. Sidgreaves, Mr. H. E. Wimperis (Vice-President).

Among the business considered by the Council was an interim report of the Education Committee; the appointment of a representative to the Czechoslovakian Aero Exhibition; the appointment of a representative on the B.E.S.A. Fans Committee; the report of the Finance Committee; the report of the Grading Committee; consideration of additional lectures to the Lecture Programme.

Elections

The following recommendations of the Grading Committee were approved by the Council at their meeting on Tuesday, October 13th, 1931:—

Associate Fellows.—Richard Milroy Clarkson, Hayne Constant, John Joseph Green (from Student), Joseph Martin Heesem (re-elected), Ernest Platton King, John Henry Broughton Larrard, Jean Pontremoli, William Norman Roberts.

Associate.—Joseph Williams.

Students.—Lorne Stuart Campbell, Noel Hogman, John Wesley Loader, Leslie Woodhouse Reeve, Alexander Phillips West.

Companions.—Robert Milroy Hayes (from Student), Thurstan T. James, Harriet Mary St. George Knightley.

Czechoslovakian Aero Exhibition

Colonel the Master of Sempill has been appointed the Society's representative at the Czechoslovakian Aero Exhibition to be held in September-October, 1932.

B.E.S.A. Committee on Fans

Mr. McKinnon Wood has been appointed the Society's representative to the B.E.S.A. Committee on Fans.

College of Aeronautical Engineering

Mr. C. R. Fairey, M.B.E., has joined the Advisory Council of the College of Aeronautical Engineering, Chelsea, in the capacity of President of the Society.

Acknowledgments

The Council acknowledge gratefully an old French coloured print, "Moyen infaillible d'enlever les Ballons," from Colonel N. Belaiew, C.B., M.I.Ae.E.

Corrections

The following corrections should be made in the paper on "The Metalclad Airship," by Mr. Carl B. Fritsche:—

Page 859, line 35, should read: 8.20lbs. per sq. ft. or 1.57in. H_2O.

Page 860, line 30, should read:

$$P\ (6{,}640{,}000 \times 2)/(3.14 \times 66^2) = 14.7 \text{ lbs./sq. ft.} = 2.82\text{in. } H_2O.$$

Membership Badges

For those members of the Society who wish to have them, a badge has been prepared. The badge shows the symbols of the Society, the peregrine and balloon, in finely chased gilt on a blue enamel background, surrounded by a royal blue border on which appears the lettering "The Royal Aeronautical Society, 1866." The badges have been hand made with the greatest care so that they will always retain their original appearance, and it is hoped that members will wear them on all suitable occasions. The price is 5/- or 5/3 post free.

Forthcoming Events

Wednesday, November 4th.—Lecture before Radley College by Major D. H. Kennedy, O.B.E., F.R.Ae.S.

Thursday, November 5th.—Lecture, "Safety in Spinning," by Mr. H. B. Irving, B.Sc., A.F.R.Ae.S., and Mr. A. V. Stephens, in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Monday, November 9th.—Lecture, illustrated with film, "Aeroplanes as an Aid to Mineral Exploration, and the Operation of Aircraft in Sub-Zero Temperatures," by Captain W. J. McDonough, in the Film House of the Gaumont Film Co., Wardour Street, W.1, at 6.30 p.m.

Friday, November 13th.—Lecture before University College School by Mr. W. O. Manning, F.R.Ae.S.

Tuesday, November 17th.—Inaugural Address before the Students' Section of the Royal Aeronautical Society, by Professor L. Bairstow, C.B.E., F.R.S., F.R.Ae.S., on "Applications of Aeronautical Research," in the Library of the Society, at 6.30 p.m.

Tuesday, November 17th.—Lecture before Wrekin College by Major T. M. Barlow, M.Sc.(Eng.), F.R.Ae.S.

Tuesday, November 17th.—Lecture before the Bristol Branch by Major J. S. Buchanan, O.B.E., F.R.Ae.S., on " High Speed Aircraft."

Thursday, November 19th.—Lecture, " Aircraft Vibration," by Mr. H. Constant, A.F.R.Ae.S., in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2.

Friday, November 20th.—Lecture before the Hull and Leeds Branch by Lieut.-Colonel W. Lockwood Marsh, O.B.E., M.A., LL.B., F.R.Ae.S., on " Speed in Aviation and What it Means."

Saturday, November 21st.—Lecture before Clifton College by Professor A. J. Sutton Pippard, M.B.E., D.Sc., F.R.Ae.S.

Monday, November 23rd.—Lecture before Birkenhead School by Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

Tuesday, November 24th.—Lecture before Blackpool High School by Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

Wednesday, November 25th.—Lecture before Bristol Grammar School by Professor A. J. Sutton Pippard, M.B.E., D.Sc., F.R.Ae.S.

Wednesday, November 25th.—Lecture before Westminster School by Mr. C. R. Fairey, M.B.E., F.R.Ae.S., President of the Society.

Thursday, November 26th.—Lecture before Bedford School by Major G. P. Bulman, O.B.E., A.F.R.Ae.S.

Saturday, November 28th.—Lecture before Caterham School by Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

J. LAURENCE PRITCHARD, *Secretary.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

DECEMBER, 1931

Council Meeting

A meeting of Council was held on Tuesday, November 10th, 1931, in the offices of the Society.

Present: Mr. C. R. Fairey, M.B.E., F.R.Ae.S., President, in the chair. Captain P. D. Acland, Professor L. Bairstow (Vice-President), Major T. M. Barlow, Mr. M. L. Bramson, Mr. Griffith Brewer (Vice-President), Major J. S. Buchanan, Major G. P. Bulman, Mr. A. H. Hall, Captain F. T. Hill, Mr. J. E. Hodgson (Hon. Librarian), Mr. W. O. Manning, Colonel the Master of Sempill (Past-President), Mr. H. E. Wimperis (Vice-President), Mr. R. McKinnon Wood.

Among the business considered by the Council was:—An interim report of the Education Committee; the report of the Finance Committee; the report of the Grading Committee; the Aero Exhibition in Athens in March, 1932; nominations for the Guggenheim Medal.

Annual Summary

This month's Journal contains a summary of the Society's activities during the past year. This summary will be supplemented by the Annual Report of Council which will appear as usual in the March issue. A number of the usual notices, *e.g.*, Elections, appear in the summary and are not printed in the Monthly Notices.

Subscriptions

Members are reminded that their subscriptions are due on January 1st, 1932. The Society, like all other institutions, is passing through a difficult time, and the Council hope that every member will make every effort to pay his subscription as early as possible in the new year. The rates are:—

	Home.			Abroad.		
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Fellow	4	4	0	3	3	0
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Associate	*2	2	0	*2	2	0
Student	1	1	0	1	1	0
Companion	2	2	0	2	2	0
Founder Member	2	2	0	2	2	0

* £1 1s. 0d. without Journal.

The Aeronautical Diary, 1932

The Aeronautical Diary for 1932 has just been published by Messrs. Gale and Polden. For those who are members of the Society, the diary is obtainable with the Society's crest on it in gold. The diary contains very full information

of aeronautical bodies, flying clubs, civil flying schools, aircraft and aero engine manufacturers, commercial and light aircraft, aero engines, notes on licensing private pilots, air touring facilities, air stations, air records and aircraft making, as well as tables and other information of interest to airmen, forthcoming lectures, etc. It is hoped that every member of the Society will buy a copy of the diary, for by buying it every member is directly helping the Society, as a percentage of the profits from all copies sold is being given by the publishers to the Endowment Fund. The prices of the diary are as follows:—Bound in blue cloth, without loop and pencil, 1s. 6d. net; in blue cloth, with loop and pencil, 2s. net; in royal blue leather, with loop and pencil, 3s. net; in refill form in solid blue morocco leather wallets, 7s. 6d.

Applications for the Aeronautical Diary should be made direct to Messrs. Gale and Polden, Aldershot, and not to the offices of the Society.

Forthcoming Events

Tuesday, December 1st.—Lecture before Tonbridge School by Mr. J. E. Hodgson.

Thursday, December 3rd.—Lecture, "Wheel Brakes and Undercarriages," by Mr. S. Scott-Hall, M.Sc., D.I.C., A.F.R.Ae.S., in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Thursday, December 3rd.—Lecture before the Gloucester and Cheltenham Branch by a member of the Cierva Autogiro Co., on "The Autogiro."

Friday, December 4th.—Lecture before Hurstpierpoint College by Captain J. Laurence Pritchard, Hon.F.R.Ae.S.

Friday, December 4th.—Lecture before the Bristol Branch by Mr. E. F. Relf, F.R.Ae.S., on "Aeronautical Research Development."

Tuesday, December 8th.—Lecture before Beaumont College by Major T. M. Barlow, F.R.Ae.S.

Thursday, December 10th.—Lecture, "Airflow," by Mr. W. S. Farren, M.B.E., F.R.Ae.S., M.I.Ae.E., with demonstrations on the screen by means of smoke, in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Thursday, December 10th.—Lecture before the Yeovil Branch by Mr. J. R. Ashwell-Cooke, Chairman of the London Gliding Club, on "The Gliding Movement in England and Germany."

Thursday, December 10th.—Lecture before the Imperial Service College, Windsor, by Major T. M. Barlow, F.R.Ae.S.

Friday, December 11th.—Lecture before the Hull and Leeds Branch by Mr. I. J. Gerard, M.Sc., Assoc.M.Inst.C.E., A.F.R.Ae.S., on "Tests of Aircraft Structures and Components."

Tuesday, December 15th.—Lecture before the Borough Polytechnic Engineering Society by Mr. D. Hay Surgeoner, Stud.R.Ae.S.I.

Thursday, December 17th.—Lecture, "Control beyond the Stall," by Dr. G. V. Lachmann, A.F.R.Ae.S., in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m.

Thursday, December 17th.—Lecture before the Yeovil Branch by Captain G. P. Olley, of Imperial Airways, Ltd., on "Twelve Years' Progress in Commercial Aviation."

J. LAURENCE PRITCHARD, *Secretary*.

TECHNOLOGY DEPT.

PUBLICATIONS

OF THE

ROYAL AERONAUTICAL SOCIETY

with which is incorporated The Institution of Aeronautical Engineers.

Corrected to May, 1931.

TOGETHER WITH

A CLASSIFIED LIST OF ARTICLES

FROM

The JOURNAL of the Society for 1917-1931.

7, ALBEMARLE STREET, LONDON, W.1.

Annual Reports of the Aeronautical Society.

These Reports, which were issued annually from 1866-1897, when they were replaced by THE AERONAUTICAL JOURNAL, form a complete record of the pioneer work that was done during that period and are of great historical interest and value. As many of these volumes are now extremely rare special prices will be forwarded on application.

The Journal of The Royal Aeronautical Society

with which is incorporated

The Institution of Aeronautical Engineers.

The Official Organ of the Society, containing original articles and full reports of all Papers read before the Members, together with discussions thereon.

Annual Subscription: £2 4s. 6d., post free, Home or Abroad;

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(NOTE.—A classified list of important articles published in the Journal from January 1917, to May, 1931, is given in this pamphlet. The price of Journals which are more than one month old cannot be guaranteed, and an inquiry should be made before ordering.)

The Aeronautical Classics.

Reprints of the Work of the Early Pioneers on whose theories modern flight is based.

1. "Aerial Navigation," by Sir George Cayley (1809) ... ... O.P.
2. "Aerial Locomotion," by F. H. Wenham (1866) 5/-
3. "The Art of Flying," by Thomas Walker (1810) 1/6
4. "The Aerial Ship," by Francesco Lana (1670) 5/-
5. "Gliding," by Percy S. Pilcher (1897) 2/6
6. "The Flight of Birds," by G. A. Borelli (1680) 1/-

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"Report of the Bird Construction Committee" (1911) 10/6

Transactions of the Royal Aeronautical Society.

Original Papers of a Fundamental Character in the Science of Aeronautics.

No.	Title	Price
1.	"The Calculation of Stresses in Aeroplane Wing Spars," by Arthur Berry, M.A.	5/-
2.	"Position Fixing in Aircraft during Long Distance Flights over the Sea," by Instructor-Commander T. Y. Baker, R.N., and Major L. N. G. Filon, D.Sc., F.R.S., late R.A.F.	5/-
3.	"Aero Engine Efficiencies," by Dr. A. H. Gibson	5/-

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REPRINTS.

The following reprints of important Papers read before the Society are available:

No.	Title	Price
2.	"Methods of Measuring Aircraft Performances," by Captain H. T. Tizard, 1917	1/6
3.	"The Screw Propeller in Air," by M. A. S. Riach, 1917	2/6
4.	"The High Tension Magneto," by A. P. Young, 1917	10/-
5.	"Commercial Aeronautics," by G. Holt Thomas, 1918	2/6
7.	"Steel Tubes, Tube Manipulation and Tubular Structures for Aircraft," by W. W. Hackett and A. G. Hackett, 1918	2/6
9.	"Design of Aeroplane Struts," by W. H. Barling, A.R.C.Sc., B.Sc., and H. A. Webb, M.A., 1918	2/6
10.	"Stress Optical Experiments," by Major A. R. Low, 1919	5/-
12.	"Struts of Conical Taper," by H. A. Webb, M.A., and Miss E. D. Lang, M.A., 1919	1/6
19.	"Valve Steels," by P. B. Henshaw, 1927	10/-
20.	"The Generation of Vortices in Fluids of Small Viscosity," by Dr. L. Prandtl. 1927	5/-
21.	"Recent Model Experiments in Aerodynamics," by E. G. Richardson, B.A., M.Sc., Ph.D., 1927	5/-
22.	"Parachutes," by Flight-Lieutenant F. O. Soden, 1927	2/6

No.	Title	Price
23.	"Safety from Fire in Airships," by Wing-Commander T. R. Cave-Browne-Cave, C.B.E., F.R.Ae.S., A.M.I.Mech.E., 1927 ...	2/6
24.	"Secondary Stresses in Airship Hull Structures," by J. F. Baker, M.A., 1927	2/6
27.	"The Problem of the Long-Range Flying Boat," by Major J. D. Rennie, A.R.T.C., A.M.Inst.C.E., F.R.Ae.S.	5/-
28.	"Fog," by Captain F. Entwistle, B.Sc., 1928	5/-
29.	"Modern Developments in Aircraft Instruments," by Major C. J. Stewart, O.B.E., M.I.Mech.E., F.R.Ae.S., M.I.A.E., 1928 ...	5/-
30.	"Experiments on Model Airscrews at High Tip Speeds," by G. P. Douglas, M.C., D.Sc., 1928	5/-
31.	"The Variable Pitch Airscrew," by H. S. Hele-Shaw, D.Sc., LL.D., F.R.S., M.Inst.C.E., and T. E. Beacham, B.Sc., A.C.G.I., A.M.Inst.C.E., 1928	5/-
32.	"The 16th Wilbur Wright Memorial Lecture (Slots)," by F. Handley Page, C.B., F.R.Ae.S., 1928	5/-
33.	"Notes on a Family of Similar Flying Boats," by C. Dornier, 1928	5/-
34.	"The Use of Light Alloys in Aircraft from the Point of View of Corrosion," by H. Sutton, M.Sc., A.F.R.Ae.S., 1928	5/-
35.	"The Testing of Adhesives for Timber," by W. D. Douglas, F.R.C.Sc.I., A.M.I.E.E., A.F.R.Ae.S., and C. B. Pettifor, B.Sc., 1929	5/-
36.	"The Machinery Installation of Airship R.101," by Wing-Commander T. R. Cave-Browne-Cave, C.B.E., A.M.I.Mech.E., A.M.I.N.A., F.R.Ae.S., 1929	5/-
37.	"Steel Tubes Manipulation and Tubular Structures for Aircraft," by W. W. Hackett, and "Stainless Steel and Iron," by W. Hackett Junr., 1929	2/6
38.	"Weight of Aircraft," by Major T. M. Barlow, M.Sc., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., 1929	5/-
39.	"Air-Cooled Engines in Service," by A. H. R. Fedden, F.R.Ae.S., 1929	5/-
40.	"The Streamline Aeroplane," by B. Melville Jones, A.F.C., M.A., F.R.Ae.S., 1929	3/6
41.	"The Flutter of Aeroplane Wings." by R. A. Frazer, F.R.Ae.S., 1929	5/-
42.	"Monoplane or Biplane," by W. S. Farren, F.R.Ae.S., 1929 ...	5/-
43.	"The Helicogyre," by V. Isacco, 1929	5/-
44.	"The Cruise of the Royal Air Force Far East Flight," by Group-Captain H. M. Cave-Browne-Cave, D.S.O., D.F.C., F.R.Ae.S., 1929	5/-
45.	"Airscrew Body Interference," by C. N. H. Lock, M.A., A.F.R.Ae.S.	5/-

No.	Title	Price
46.	"R.101," by Lieut.-Col. V. C. Richmond, O.B.E., B.Sc., F.R.Ae.S.	5/-
47.	"The External Forces on an Airship Structure, with Special Reference to the Requirements of Rigid Airship Design," by H. Roxbee Cox, Ph.D., D.I.C., A.F.R.Ae.S.	5/-
48.	"French Wind Tunnel Methods," by A. Lapresle	5/-
49.	"Handling and Mooring of Airships," by Major G. H. Scott, C.B.E., A.F.C., F.R.Ae.S.	2/6
50.	"Prospects of Civil Aviation in East Africa," by F. Tymms, M.C., A.F.R.Ae.S.	5/-
51.	"The Lubrication of Aircraft Engines," by F. A. Foord, A.F.R.Ae.S.	10/-
52.	"Science in Relation to Regulating and Promoting Civil Aviation," by the Hon. Wm. P MacCracken, Jun.	5/-
53.	"Strength of Transverse Frames of Rigid Airships," by Miss H. M. Lyon, M.A., A.F.R.Ae.S.	5/-
54.	"Ten Years' Gliding and Soaring in Germany," by Dr. W. Georgii ...	5/-
55.	"Resistance of Air-Cooled Engines" and "The Townend Ring," by Major F. M. Green, O.B.E., A.M.Inst.C.E., F.R.Ae.S., and Mr. H. C. H. Townend, A.F.R.Ae.S.	5/-
56.	"The Equilibrium of Loaded Impeller Blades, with Special Reference to the Strength of Thin Metal Airscrews," by P. A. Ralli, A.F.R.Ae.S.	5/-
57.	"The Origin and Development of Heavy Oil Engines," by D. R. Pye, M.A. F.R.Ae.S.	5/-

Miscellaneous Publications.

Consolidated Subject Index to the Journal of the Royal Aeronautical Society. 2s. 6d. net.

This is a complete index of all articles and papers which have appeared in the Journal for 1897-1926 inclusive.

Catalogue of the Library of the Royal Aeronautical Society. Price 5/-.
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The Report of the International Air Congress, London, 1923. 25/-.

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Published under the authority of the Council: Handbook of Aeronautics, an international book of reference for aeronautical engineers. 25/- net (25/9 post free).

Publications of the Institution of Aeronautical Engineers.

MINUTES OF PROCEEDINGS.

1923.

No.

3. "Aeroplane Design," H. P. Folland, F.R.Ae.S., M.B.E., M.I.Ae.E. 4/6

4. "Constructional Design of Aeroplanes" (in three sections), C. W. Tinson, F.R.Ae.S., M.I.Ae.E.

"Oleo Undercarriage Design," G. H. Dowty, A.F.R.Ae.S., M.I.Ae.E. 4/6

5. "Experimental Data without a Wind Channel," Major O. T. Gnosspelius, A.C.G.I., A.F.R.Ae.S., M.I.Ae.E.

"Gliding and Gliders at Itford." A Discussion led by W. O. Manning, F.R.Ae.S., M.I.Ae.E.

"Wind Tunnel Work at the National Physical Laboratory," W. L. Cowley, A.R.C.Sc., D.I.C., M.I.Ae.E.

Report of Fifth Annual Meeting, with Presidential Address and Lecture on "Aerial Photography," by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., M.P., F.R.Ae.S., M.I.Ae.E. 4/6

6. "Some Controversial Points in Aircraft Detail Design," F. T. Hill, B.Sc., Wh.Ex., F.R.Ae.S., M.I.Ae.E.

"Low-Powered Flying," Squadron-Leader M. E. A. Wright, A.F.C.

"Some Aspects of an Attempt to Fly Round the World," Major W. T. Blake, A.M.I.Ae.E. 3/6

1924.

7. "Welded Steel Tube Construction and the Development of Cantilever Wings," A. H. G. Fokker 4/6

8. "Three-Ply and its Uses in Aircraft Construction," Capt. R. N. Liptrot, B.A.

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9. "The Loth Leader Cable System for Electrical Steering of Aeroplanes," W. Loth and John Gray, B.Sc., M.I.E.E.

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10. "Some Problems in Connection with the Structure of Rigid Airships," Lieut.-Col. V. C. Richmond, O.B.E., B.Sc., F.R.Ae.S.

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12. "Braided Rubber Shock-Absorber Cord for Aircraft," L. Rowland, B.Sc., A.M.Inst.C.E.

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13. "Commercial Airship Design," Capt. F. L. M. Boothby, C.B.E., F.R.Ae.S.

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14. "The History and Evolution of the Avro Training Machine," R. J. Parrott, A.C.G.I., M.I.Ae.E. 4/6

15. "A Few Experiments with Shock-Absorbing Hulls for Flying Boats," Lieut. N. Olechnovitch, M.I.Ae.E.

"The Position of the Airship in Aerial Transport," Lieut.-Comdr. C. D. Burney, C.M.G., M.P., R.N. (Retd.).

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18. "Some Aspects of Full-Scale Experiments," C. Howarth, A.F.R.Ae.S., M.I.Ae.E.

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19. "Practical Flying," M. L. Bramson, A.C.G.I., F.R.Ae.S., M.I.Ae.E.

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"Some Reminiscences of Ten Years Ago," Lawrence A. Wingfield, M.C., D.F.C., A.R.Ae.S.I. 5/-

Feb. "Unsolved Aeronautical Problems," M. L. Bramson, A.C.G.I., F.R.Ae.S., M.I.Ae.E.

"Aircraft Alighting and Arresting Mechanisms," G. H. Dowty, A.F.R.Ae.S., M.I.Ae.E. 5/-

Mar. "Wind Structure in Relation to Air Navigation," Captain F. Entwistle, B.Sc.

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April. "Some Notes on the Possibilities of Progress in Aviation," A. G. Von Baumhaer.

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July. "Flying for Air Survey Photography," Captain F. Tymms, M.C., A.F.R.Ae.S.

"Portable Hangars," Major H. N. Wylie, B.Sc., F.R.Ae.S.

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Aug. "Heat-Resisting and Non-Corrodible Steels," S. A. Main, B.Sc., F.Inst.P. of the Hadfield Research Laboratories, Sheffield.

"The Application of Insecticides by Aeroplane," Dudley Wright, A.M.I.Ae.E. 3/6

Sept. "Some Further Practical Points in the Structural Design of Aircraft," A. P. Thurston, D.Sc., M.B.E., F.R.Ae.S., M.I.Ae.E.

"Notes on Seaplane Design," Commander J. C. Hunsaker (C.C.), U.S.N., D.Sc., Hon.F.R.Ae.S. 3/6

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(These are abstracts, prepared by the Air Ministry, of articles on aviation and allied subjects, from the scientific and technical Press of the world. The following list gives the dates when each one of the series has been published in the Journal.)

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Medical

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Miscellaneous

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Handbook of Aeronautics. Published under authority of the Council of the Royal Aeronautical Society. (Pitman) 1938-1941. 3 vols. 30s., 25s., 20s.

AERODYNAMICS

BAIRSTOW, L. *Applied Aerodynamics.* (Longmans, Green) 1939. 65s.

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JONES, BRADLEY. *Elements of Practical Aerodynamics.* (Chapman & Hall) 1939. 22s. 6d.

LIPTROT, R. N. *Handbook of Aeronautics.* Part II, *Performance.* (Pitman) 1937. 6s.

PIERCY, N. A. V. *Aerodynamics.* (English Universities Press) 1937. 30s.

RELF, E. F. *Handbook of Aeronautics.* Part I, *Aerodynamics.* (Pitman) 1937. 6s.

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NELSON, W. *Airplane Lofting.* (McGraw-Hill) 1941. 12s. 6d.

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PIPPARD, A. J. S., and PRITCHARD, J. L. *Aeroplane Structures.* (Longmans, Green) 1935. 24s.
WILKINS, E. W. C. *Aeroplane Design.* (Griffin) 1938. 22s.
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Handbook of Aeronautics. Vol. II. (Pitman) 1938. 25s.

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Aero Engines, Vol. II. (Griffin) 1939. 18s.
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INSTITUTE OF PETROLEUM. *Proceedings.* (The Institute, Birmingham)
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MORLEY, A. *Strength of Materials.* (Longmans, Green) 1940. 15s.
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TIMOSHENKO, S. *Theory of Elastic Stability.* (McGraw-Hill) 1936. 42s.
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Vibration Problems in Engineering. (Constable) 1937. 24s.
TIMOSHENKO, S., and YOUNG, D. M. *Engineering Mechanics.* (McGraw-Hill) 1941. 28s.
WILSON, W. KER. *Practical Solution of Torsional Vibration Problems.* (Chapman & Hall) 1940-1941. 2 vols. 42s. each.

GLIDERS AND GLIDING FLIGHT

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MATHEMATICS

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LANCHESTER, F. W. *Theory of Dimensions and Its Application for Engineers.* (Author, Dyott End, Oxford Road, Mosely, Birmingham) 1936. 12s. 6d.
ROSE, W. N. *Mathematics for Engineers.* (Chapman & Hall) 1937. 2 vols. Vol. I 10s. 6d., vol. II 13s. 6d.
SOUTHWELL, R. V. *An Introduction to the Theory of Elasticity for Engineers and Physicists.* (Oxford University Press) 1936. 30s.
Relaxation Methods in Engineering Science. (Oxford University Press) 1940. 17s. 6d.
STONEY, J. *Calculus for Engineers and Students of Science.* (Pitman) 1941. 7s. 6d.

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BROWN, F. G. *Air Navigation.* (Chapman & Hall) 1941. 32s.
CHICHESTER, F. *The Observer's Book on Astro-Navigation.* (Allen & Unwin) 1941. 3 parts. 2s. 6d. each. Part 4 in preparation, 4s. 6d.
DEBENHAM, F. *Astrographics.* (Heffer, Cambridge) 1942. 7s. 6d.
LEGG, P. H. *An Introduction to Astronomical Navigation.* (Chapman & Hall) 1939. 12s.
MARTIN, C. W. *Air Navigation.* (Eversley Press) 1938. 25s.
WEEMS, P. V. H. *Air Navigation.* British Empire Edition. (McGraw-Hill) 1937. 30s.

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CROOK, W. E. *D/F Handbook for Wireless Operators.* (Pitman) 1941. 3s. 6d.
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REYNER, J. H. *Modern Radio Communication.* (Pitman) 1941-42. 2 vols. 7s. 6d. each.
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